PUBLICATIONS

OF THE

ASTRONOMICAL SOCIETY

OF THE PACIFIC.

VOLUME X.
1898.

SAN FRANCISCO
PRINTED FOR THE SOCIETY.
1898.

MICROFILM AVAILABLE

PAGE

LELAND

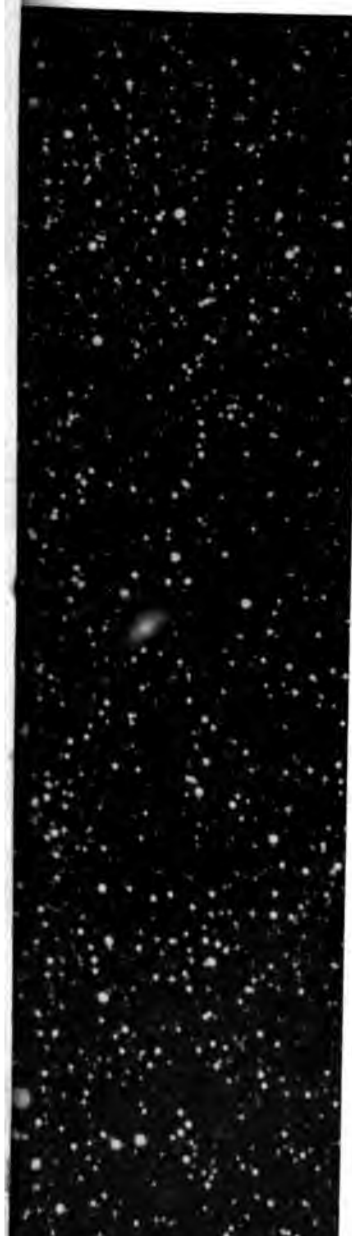


TABLE OF CONTENTS.*

Publications No. 60, February 1, 1898.

* **To the Binder**: This should precede page 1, Volume X.

Publications No. 61, April 2, 1898.

Publications No. 62, June 1, 1898.

Publications No. 63, August 1, 1898.

Publications No, 64, October 1, 1898.

Publications No. 65, December 1, 1898.

PUBLICATIONS

OF THE

Astronomical Society of the Pacific.

VOL. X. SAN FRANCISCO, CALIFORNIA, FEBRUARY 1, 1898. No. 60.

LIST OF MEMBERS

OF THE

ASTRONOMICAL SOCIETY OF THE PACIFIC.

JANUARY 1, 1898.

OFFICERS OF THE SOCIETY.

Mr. WILLIAM ALVORD (Bank of California, S. F.) . . . . *President*
Mr. E. J. MOLERA (606 Clay Street, S. F.) . . . . . .
Mr. FREDERICK H. SEARES (Berkeley, Cal.) . . . . . . *Vice-Presidents*
Mr. C. M. ST. JOHN (U. S. Custom House, S. F.) . . . . .
Mr. C. D. PERRINE (Lick Observatory) . . . . *Secretary*
Mr. F. R. ZIEL (301 California Street, S. F.) . . . . *Secretary and Treasurer*

Board of Directors—Messrs. ALVORD, MOLERA, MORSE, Miss O'HALLORAN, Messrs. PERRINE, PIERSON, SEARES, ST. JOHN, TUCKER, VON GELDERN, ZIEL.
Finance Committee—Messrs. WM. M. PIERSON, E. J. MOLERA, and C. M. ST. JOHN.
Committee on Publication—Messrs. AITKEN, BABCOCK, SEARES.
Library Committee—Messrs. HUSSEY and SEARES and Miss O'HALLORAN.
Committee on the Comet-Medal—Messrs. SCHAEBERLE and CAMPBELL.

OFFICERS OF THE CHICAGO SECTION.

Executive Committee—Mr. RUTHVEN W. PIKE.

OFFICERS OF THE MEXICAN SECTION.

Executive Committee—Mr. FRANCISCO RODRIGUEZ REY.

LIST OF MEMBERS.*

Mr. CARL H. ABBOTT . . . . 118 11th St., Oakland, Cal.
Prof. R. G. AITKEN . . . . Lick Observatory, Mt. Hamilton, Cal.
Mr. J. H. ALBERT . . . . Salem, Oregon.
Prof. W. STEADMAN ALDIS, *F.R.A.S. . . Kidlington, near Oxford, England.
Prof. W. D. ALEXANDER . . . . Honolulu, Hawaiian Islands.
Mr. RICHARD H. ALLEN* . . . . Chatham, Morris Co., N. J.
Mr. CHARLES ALTSCHUL . . . . London, Paris and American Bank, S. F., Cal.

* A star signifies Life Membership. Total membership, 349 (75 life members.)

Hon. HENRY B. ALVORD* . . . . San José, Cal.
Hon. WILLIAM ALVORD* . . . . 2200 Broadway, S. F., Cal.
Mrs. WILLIAM ALVORD* . . . . 2200 Broadway, S. F., Cal.
Miss KATE AMES . . . . Napa, Cal.
Mr. W. S. ANDREWS . . . . Schenectady, N. Y.
Mr. F. S. ARCHENHOLD . . . . Treptow Sternwarte, bei Berlin, Germany.
Mrs. WM. ASHBURNER . . . . 1014 Pine St., S. F., Cal.
Mr. J. J. AUBERTIN,* F.R.A.S. . . . . . 33 Duke St., St. James, S. W., London, England.
Mr. ALLEN H. BABCOCK . . . . 1214 Webster St., Oakland, Cal.
Mr. WALTER C. BAKER . . . . 1467 Euclid Ave., Cleveland, Ohio.
Mr. N. A. BALDWIN . . . . New Haven, Conn.
Mr. J. BASSETT . . . . 82 High St., Stoke Newington, N. England.
Miss FRANCES L. BEANS . . . . 489 N. First St., San José, Cal.
Mr. HENRY BERGER . . . . Observatory Hill, Allegheny, Pa.
Mr. JOHN BERMINGHAM* . . . . 330 Market St., S. F., Cal.
Prof. ALBERT S. BICKMORE . . . . . American Museum of Natural History, Central Park, New York, N. Y.
Prof. FRANK H. BIGELOW . . . . . . U. S. Weather Bureau, Washington, D. C.
Mr. WILBERT M. BIRGE . . . . Davenport, Neb.
Mr. R. L. BISCHOFFSHEIM,* F.R.A.S. . . 3 Rue Taitbout, Paris, France.
Mr. CHARLES R. BISHOP . . . . Occidental Hotel, S. F., Cal.
Mr. THOMAS B. BISHOP* . . . . 532 Market St., S. F., Cal.
Mr. ANSON STILES BLAKE . . . . Berkeley, Cal.
Mr. CHARLES T. BLAKE . . . . Berkeley, Cal.
Mr. HENRY LORD BOULTON, Jr.,*F.R.A.S. Carácas, Venezuela, or Box 2015, New York, N. Y.
Dr. J. T. BOYD . . . . 76 E. Ohio St., Indianapolis, Ind.
Colonel E. D. BOYLE . . . . Gold Hill, Storey Co., Nev.
Mr. FREDERICK E. BRASCH . . . . . . Stanford University, Cal.
Mr. J. A. BRASHEAR, F.R.A.S. . . . . . Allegheny City, Pa.
Rev. M. S. BRENNAN . . . . St. Lawrence's Church, St. Louis, Mo.
Rev. A. L. BREWER . . . . San Mateo, Cal.
Mr. EDWARD M. BREWER . . . . 27 Kilby St., Boston, Mass.
Mr. JOSEPH BROOKS, F.R.A.S., F.R.G.S. Hope Bank, Nelson St., Woollahra, via Sydney, New South Wales.
Col. ALEX. BURTON-BROWN, R.A., F.R.A.S. St. George's Club, Hanover Square, London, England.
Miss E. BROWN* . . . . Further Barton, Cirencester, England.
Miss C. W. BRUCE* . . . . 810 5th Ave., New York, N.Y.
Mr. CHARLES BURCKHALTER, F.R.A.S. Chabot Observatory, Oakland, Cal.

Miss MARY E. BYRD	The Observatory, Smith College, Northampton, Mass.
Dr. J. CALLANDREAU*	114 Montgomery St., S. F ,Cal.
Prof. W. W. CAMPBELL	Lick Observatory, Mt. Hamilton, Cal.
Mr. ANDREW CARNEGIE*	5 West 51st St.,New York,N.Y.
Mr. J. C. CEBRIAN*	Pine and Octavia Sts., S. F., Cal.
Dr. V. CERULLI	Observatorio Privato, Teramo, Italy.
Mr. B. G. CLAPP	The Academy, Fulton, N. Y.
Dr. E. S. CLARK	16 Geary St., S. F., Cal.
Miss ISABELLA D. CLARK	San José, Cal.
Mr. MATEO CLARK*	27 Queen's Gate, London, England.
Miss AGNES M. CLERKE	68 Redcliffe Square, London, England.
Mr. ERNEST A. CLEVELAND	Vancouver, B. C.
Mr. E. F. CODDINGTON	Lick Observatory, Mt. Hamilton, Cal.
Mr. A. L. COLTON*	Box 1314, Ann Arbor, Mich.
Mr. J. COSTA	114 Montgomery St., S. F., Cal.
Mr. HENRY COWELL*	413 Hyde St., S. F., Cal.
Mr. HUGH CRAIG	312 California St., S. F., Cal.
Mr. WALTER CRAMP	1229 North Broad St., Philadelphia, Pa.
Mr. GEORGE CROCKER*	Mills Building,New York, N.Y.
Mr. HENRY J. CROCKER	508 California St., S. F., Cal.
Mr. WILLIAM H. CROCKER*	Crocker-Woolworth National Bank, S. F., Cal.
Mr. EDWARD CROSSLEY,* F.R.A.S.	Bermerside Observatory, Halifax, England.
Miss S. J. CUNNINGHAM	Swarthmore College, Delaware Co., Pa.
Mr. CHAS. S. CUSHING	920 Linden St., Oakland, Cal.
Mr. J. EWEN DAVIDSON*	Alexandra Plantation, Branscombe, Mackay, Queensland.
Mr. JOSEPH E. DAVIS	154 Beacon St., Boston, Mass.
Mr. WILLIAM T. DAWSON	Etna, Siskiyou Co., Cal.
Mr. C. W. DEARBORN	Care Oakland Bank of Savings, Oakland, Cal.
Mrs. JOHN H. DEVEREUX	882 Euclid Ave., Cleveland, Ohio.
Mr. W. H. DEVINE*	Nagasaki, Japan.
Miss GRACE H. DODGE	262 Madison Avenue, New York, N. Y.
Mr. JOHN DOLBEER	10 California St., S. F., Cal.
Mr. W. E. DOWNS	Sutter Creek, Amador Co., Cal.
Mrs. ANNA PALMER DRAPER*	271 Madison Ave., New York, N. Y.
Rev. W. ARTHUR DUCKWORTH, J. P.	Orchardleigh, Frome, Somerset, England.

Mr. FRANCIS G. DU PONT	Wilmington, Del.
Mr. H. DUTARD*	2616 Buchanan St., S. F., Cal.
Mr. EARNEST I. DYER	1383 Alice St., Oakland, Cal.
Miss S. J. EASTMAN	Ogontz School, Pa.
Mr. GEO. M. EDGAR	University P. O., Tuscaloosa Co., Alabama.
Mr. GEO. W. EDWARDES	533 South Orange St., Media, Pa.
Prof. GEORGE C. EDWARDS	Berkeley, Cal.
Mr. HENRY EICHBAUM	3 Devonshire Terrace, Ventnor, Isle of Wight, England.
Capt. OLIVER ELDRIDGE	615 Sutter St., S. F., Cal.
Mr. J. W. ERWIN	2647 Durant Ave., Berkeley, Cal.
Hon. ROBERT ISAAC FINNEMORE,* F.R.A.S.	Puisne Judge, Supreme Court, Pietermaritzburg, Natal, South Africa.
Mr. S. WILSON FISHER	1502 Pine St., Philadelphia, Pa.
Mr. ANDREW B. FORBES*	401 California St., S. F., Cal.
Mr. GEO. STUART FORBES	Care King, King & Co., East India Agents, Bombay, India.
Mr. ARTHUR W. FOSTER*	322 Pine St., S. F., Cal.
Mr. C. L. FOSTER	601 Polk St., S. F., Cal.
Mr. H. C. FRICK*	42 5th Ave., Pittsburgh, Pa.
Prof. CHAS. W. FRIEND	Observatory, Carson, Nev.
Mr. ROBERT D. FRY*	1812 Jackson St., S. F., Cal.
Mr. WALTER F. GALE, F.R.A.S.	Paddington, Sydney, N. S. W.
Mr. JOS. F. GASSMANN	318 Montgomery St., S. F., Cal.
Miss GEARON	St. Margarets', Barrowgate Road, Chiswick, England.
Mr. OTTO VON GELDERN	Room 56, 819 Market St., S.F., Cal.
Mr. LOUIS GEX	Santos, Brazil.
Dr. DAVID GILL, C.B., F.R.A.S.	Royal Astronomer, Cape of Good Hope, Africa.
Mr. ALLEN F. GILLIHAN	2420 Fulton St., Berkeley, Cal.
Mr. GEORGE GLEASON, J. P.	South Pasadena, Los Angeles Co., Cal.
Mr. JAMES MONROE GOEWEY	Page and Laguna Sts., S. F., Cal.
Capt. CHARLES GOODALL*	S.E. cor. McAllister and Pierce Sts., S. F., Cal.
Mr. ADAM GRANT*	N. E. cor. Bush and Sansome Sts., S. F., Cal.
Mr. JOSEPH D. GRANT*	N. E. cor. Bush and Sansome Sts., S. F., Cal.
Mr. ALBERT EDWARD GRAY	Lasata, Oroville, Butte Co., Cal.
Mr. ANDREW GREIG*	3 Duntrune Terrace, Broughty Ferry, Dundee, Scotland.
Sir GEORGE GREY,* K.C.B.	Auckland, New Zealand.
Mr. C. P. GRIMWOOD	214 Pine St., S. F., Cal.
Rev. H. GRATTAN GUINNESS, D.D., F.R.A.S.	Cliff House, Curbar, via Sheffield, England.

Mr. J. O'B. Gunn	Box 2128, S. F., Cal.
Miss Estella L. Guppy	San José, Cal.
Mr. W. C. Gurley	Marietta, Ohio.
Mr. David E. Hadden	Alta, Iowa.
Mr. W. H. Hammon	U. S. Weather Bureau, Mills Building, S. F., Cal.
Mr. Henry Harrison	Maudeville Ave., Jersey City Heights, New Jersey.
Mr. Jackson Hatch	Porter Building, San José, Cal.
Mr. L. L. Hawkins	268 Oak St., Portland, Oregon.
Mr. Robert Y. Hayne, Jr.	San Mateo, Cal.
Mrs. Phebe Hearst	Room 33, 9th floor, Mills Building, S. F., Cal.
Mr. Andrew P. Henkel	317 Locust St., Walnut Hills, Cincinnati, Ohio.
Mr. David Hewes	Occidental Hotel, S. F., Cal.
Mr. George V. Hicks	532 California St., S. F., Cal.
Prof. Alfred Higbie	S.W. cor. Pierce and Pine Sts., S. F., Cal.
Hon. Henry E. Highton	4th floor, Mills Building, S. F., Cal.
Mr. Chas. B. Hill	212 Pine St., S. F., Cal.
Mr. Horace L. Hill*	124 Sansome St., S. F., Cal.
Mr. Samuel V. Hoffman,* F.R.A.S.	45 Madison Ave., Morristown, N. Y.
Mr. Charles W. Holden	30 Congress St., Boston, Mass.
Dr. E. S. Holden,* Foreign Assoc. R.A.S.	Smithsonian Institution, Washington, D. C.
Mr. S. E. Holden	Napa, Cal.
Hon. James F. Houghton	223 Mission St., S. F., Cal.
Hon. C. Webb Howard*	Pacific-Union Club, S. F., Cal.
Mr. Wm. Howat*	358 William St., Melbourne, Victoria.
Mr. Wm. Rumford Howell	4306 Walnut St., Philadelphia, Pa.
Prof. W. J. Hussey	Lick Observatory, Mt. Hamilton, Cal.
Mrs. M. H. Hutton	26 Union St., New Brunswick, New Jersey.
Imperial Observatory	University of St. Petersburg, Russia.
Mr. O. H. Ingram	Eau Claire, Wisconsin.
Mr. Frank Jaynes	W. U. Telegraph Co., S. F., Cal.
Mr. Nels Johnson	Manistee, Mich.
Prof. J. E. Keeler, F.R.A.S.	Director Allegheny Observatory, Allegheny City, Pa.
Mr. Charles C. Keeney*	2220 Clay St., S. F., Cal.
Prof. Josiah Keep	Mills College, Alameda Co., Cal.
Mr. A. Keith	Riverside, Cal.
Mr. James R. Kelly	309 Leavenworth St., S. F., Cal.

Mr. JOHN W. KENDRICK	Gen. Mgr. N.P.R.R., 230 Oak Grove St., Minneapolis, Minn.
Mr. A. E. KENNELLY* F.R.A.S.	1105 Betz Building, Philadelphia, Pa.
Mr. DONALD KING	8 Church Lane, Hornsey, London, England.
Mr. SYDNEY T. KLEIN,* F.R.A.S.	Observatory, Great Stanmore, Middlesex, England.
Dr. DOROTHEA KLUMPKE	National Observatory, Paris, France.
Mr. TORVALD KÖHL*	Odder, Denmark.
Mr. FR. KOEPPEN	Stueler Strasse 2, Berlin, W. Germany.
Prof. H. KREUTZ	Sternwarte, Kiel, Germany.
Mr. C. F. DE LANDERO*	P. O. Box 1, Pachuca, State Hidalgo, Mexico.
Mr. WALTER W. LAW	Briar Cliff, Scarborough, N.Y.
Miss HANNAH TOWNSEND LAWRENCE	Bayside, Long Island, N. Y.
Hon. MANUEL FERNANDEZ LEAL	Calle de Cordovanes No. 3, City of Mexico, Mexico.
Prof. F. P. LEAVENWORTH	University of Minnesota, Minneapolis, Minn.
Prof. JOSEPH LE CONTE, LL. D.	Berkeley, Cal.
Rev. EDMUND LEDGER, M.A., F.R.A.S.	Claydon, Ipswich, England.
Prof. D. A. LEHMAN	Berea, Ohio.
Mr. CLARENCE MACKENZIE LEWIS*	104 E. 37th St., New York, N.Y.
LIBRARY OF THE BUREAU OF EDUCATION	Washington, D. C.
CALIFORNIA STATE LIBRARY	Sacramento, Cal.
LIBRARY OF THE CHABOT OBSERVATORY	Oakland, Cal.
THE CITY LIBRARY	Lowell, Mass.
FREE PUBLIC LIBRARY	Newark, New Jersey.
FREE PUBLIC LIBRARY	Worcester, Mass.
LIBRARY OF THE LELAND STANFORD JR. UNIVERSITY	Stanford University, Cal.
LIBRARY OF THE LICK OBSERVATORY	Mount Hamilton, Cal.
LIBRARY OF THE MECHANICS' INSTITUTE	31 Post St., S. F., Cal.
THE NEWBERRY LIBRARY	Chicago, Ill.
NEW YORK PUBLIC LIBRARY	40 Lafayette Place, New York, N. Y.
LIBRARY OF THE OBSERVATORY	Georgetown College, D. C.
LIBRARY OF PRINCETON UNIVERSITY	Princeton, New Jersey.
THE PUBLIC LIBRARY	Boston, Mass.
LIBRARY OF ST. GERTRUDE'S ACADEMY	Rio Vista, Cal.
LIBRARY OF THE UNIVERSITY OF CALIFORNIA	Berkeley, Cal.
LIBRARY OF THE UNIVERSITY OF ILLINOIS	Champaign, Illinois.
LIBRARY OF THE UNIVERSITY OF INDIANA	Bloomington, Indiana.
LIBRARY OF THE UNIVERSITY OF PENNSYLVANIA	Philadelphia, Pa.

LIBRARY OF YALE UNIVERSITY	New Haven, Conn.
Mr. ADOLPH LIETZ	422 Sacramento St., S. F., Cal.
Mr. J. A. LIGHTHIPE	15 First St., S. F., Cal.
Mr. JOHN D. LOCKE	Haverhill, New Hampshire.
Mr. HENRY B. LOOMIS	Seattle, Washington.
Prof. HENRY C. LORD	Director of the McMillin Observatory, Ohio State University, Columbus, Ohio.
Mr. EDWARD G. LUKENS	200 Market St., S. F., Cal.
Mr. GEO. RUSSELL LUKENS	1350 Madison St., Oakland, Cal.
Mr. FRANK E. LUNT	Care R. G. Lunt, Los Angeles, Cal.
Miss AGNES M. MANNING	1215 Sutter Street, S. F., Cal.
Mr. MARSDEN MANSON, C.E., PH.D.	Bureau of Highways, Sacramento, Cal.
Mr. F. MARTENS	College Point, Queen's Co., New York.
Mr. CAMILO MARTIN	S. E. cor. Geary and Stockton Sts., S. F., Cal.
Hon. E. S. MARTIN	P. O. Box 75, Wilmington, N.C.
Mr. JOHN MARTIN	Puruatanga, Martinborough, Wairarapa, Wellington, New Zealand.
Mr. LOUIS C. MASTEN	2218 Clay St., S. F., Cal.
Prof. A. M. MATTOON	Scott Observatory, Parkville, Missouri.
Mr. W. H. MAW,* F.R.A.S.	18 Addison Road, Kensington, London, England.
Mr. FRANK MCCLEAN,* M.A., F.R.A.S.	Rusthall House, Tunbridge Wells, England.
Mr. F. H. MCCONNELL	19 Montgomery St., S. F., Cal.
Mr. JOHN MCDONOUGH	193 28th St., Brooklyn, N. Y.
Prof. J. M. MCIVER	South Alabama Baptist Institute, Thomasville, Alabama.
Prof. MALCOLM MCNEILL	Lake Forest, Ill.
Hon. ALBERT MILLER*	532 California St., S. F., Cal.
Prof. E. MILLER	University of Kansas, Lawrence, Kansas.
Hon. D O. MILLS*	15 Broad St., New York, N.Y.
Dr. LEWIS F. MIZZI	Constantinople, Turkey.
Mr. JAMES K. MOFFITT	First National Bank, S. F., Cal.
Mr. E. J. MOLERA,* C.E.	606 Clay St., S. F., Cal.
Mr. W. H. S. MONCK, F.R.A.S.	16 Earlsfort Terrace, Dublin, Ireland.
Dr. JORGE C. MONZON	Quezaltenango, Guatemala, Central America.
Mr. BEVERLY K. MOORE	56 Bedford St., Boston, Mass.
Mr. FREMONT MORSE, U.S.C. & G.SURVEY	P. O. Box 2512, S. F., Cal.
Mr. WILLIAM S. MOSES	Turk St., bet. Masonic and Parker Aves., S. F., Cal.
Mr. C. A. MURDOCK	2710 Scott St., S. F., Cal.

Hon. B. D. MURPHY*	San José, Cal.
Mr. CHARLES NELSON	6 California St., S. F., Cal.
Mr. H. F. NEWALL,* F.R.A.S.	Observatory of the University, Cambridge, England.
Mr. G. W. NICOLLS, F.R.A.S.	Caixa 776, Rio de Janeiro, Brazil.
Mr. P. NOORDHOFF	Groeningen, Holland.
Mr. CHARLES NORDHOFF	Coronado, Cal.
Miss ROSE O'HALLORAN	2610 Bush St., S. F., Cal.
Miss M. A. ORR	Heather Vale, Camberley, England.
Mr. T. S. PALMER	Department of Agriculture, Washington, D. C.
General W. J. PALMER	Colorado Springs, Colo.
Dr. GEORGE C. PARDEE	526 Montgomery St., S. F., Cal.
Dr. S. C. PASSAVANT	200 Post St., S. F., Cal.
Mr. EDWARD PAYSON	San Mateo, Cal.
Miss CLARA A. PEASE	High School, Hartford, Conn.
Mr. GEORGE W. PERCY	318 Boulevard Terrace, Oakland, Cal.
Hon. GEO. C. PERKINS*	Oakland, Cal.
Prof. H. B. PERKINS	Box 240, Pasadena, Cal.
Mr. A. PERRENOD	Saint-Pierre, Martinique.
Mr. C. D. PERRINE	Assis't Astronomer, Lick Observatory, Mt. Hamilton, Cal.
Hon. T. GUY PHELPS	Belmont, Cal.
Mr. HENRY PHIPPS, Jr.*	Carnegie, Phipps & Co., Pittsburgh, Pa.
Mr. SAM C. PHIPPS	Irvington, Alameda Co., Cal.
Mr. JOHN JAY PIERREPONT	1 Pierrepont Place, Brooklyn, Kings Co., N. Y.
Mr. LAWRENCE H. PIERSON	Pacific Pine Lumber Co., S. F., Cal.
Hon. WM. M. PIERSON, F.R.A.S.	4th floor, Mills Building, S. F., Cal.
Mr. RUTHVEN W. PIKE*	166 La Salle St., Chicago, Ill.
Mr. FRED. G. PLUMMER	Tacoma, Washington.
Dr. CHARLES LANE POOR, F.R.A.S.	Johns Hopkins University, Baltimore, Md.
Miss JULIET PORTER*	37 Dean St., Worcester, Mass.
Mr. CHARLES A. POST	Bayport, Long Island, N. Y.
Mr. WALTER A. POST	Newport News, Va.
Mr. WM. APPLETON POTTER	39 W. 27th St., New York, N.Y.
Mr. ENOS PUTMAN*	Grand Rapids, Michigan.
Mr. J. C. RABE	P. O. Box 301, Mare Island, Vallejo, Cal.
Mr. F. B. RANDALL, U.S.R.M.	U. S. Rev. Str. "Rush," S. F., Cal.
Sister ANNA RAPHAEL	College of Notre Dame, San José, Cal.
Mr. ALBERT RAYMOND	202 Sansome St., S. F., Cal.
Mr. NORMAN B. REAM	1901 Prairie Ave., Chicago, Ill.

Prof. J. K. Rees, F.R.A.S.	Observatory of Columbia College, New York, N. Y.
Colonel C. McC. Reeve	First Minnesota N. G., Minneapolis, Minn.
Mr. M. Reiman	4325 Drexel Boulevard, Chicago, Ill.
Mr. Francisco Rodriguez Rey	National Observatory, Tacubaya, Mexico.
Rev. J. L. Ricard, S. J.	Santa Clara, Cal.
Mrs. William Gorham Rice	Washington, D. C.
Mr. Daniel S. Richardson	Cor. Lincoln and Summit Sts., East Oakland, Cal.
Mr. Alexander W. Roberts	14 Lindsay Place, Leith, Scotland.
Hon. Arthur Rodgers	Nevada Block, S. F., Cal.
Mrs. Arthur Rodgers*	Leavenworth and Vallejo Sts., S. F., Cal.
Dr. W. H. Rollins	250 Marlboro St., Boston, Mass.
Mr. Geo. A. Ross	1405 Ninth Ave., East Oakland, Cal.
The Earl of Rosse, F.R.A.S.	Birr Castle, Parsonstown, Ireland.
Baron Albert von Rothschild*	Vienna, Austria.
Mr. John R. Ruckstell	182 Crocker Bld'g, S. F., Cal.
Mr. Alexander Rydzewski	Officer St., House 13, Lodging 26, St. Petersburg, Russia.
Mr. G. N. Saegmuller	Care Fauth & Co., Maryland Ave., Washington, D. C.
Mr. Joseph C. Sala	429 Montgomery St., S. F., Cal.
Mr. John W. Salsbury	Clear Water Harbor, Florida.
Prof. J. M. Schaeberle*	Lick Observatory, Mt. Hamilton, Cal.
Mr. Jacob H. Schiff*	932 Fifth Ave., New York, N. Y.
Mr. Herman Schussler	Pacific-Union Club, S. F., Cal.
Baron A. v. Schweiger-Lerchenfeld	Kleine Neugasse 13, Vienna, Austria.
Mr. Henry T. Scott	Box 2128, S. F., Cal.
Mr. James L. Scott, F.R.A.S.	Care Turnbull, Howie & Co., Shanghai, China.
Rev. George M. Searle	Catholic University of America, Brookland, D. C.
Mr. Frederick H. Seares	Berkeley, Cal.
Dr. J. M. Selfridge	Box 37, Oakland, Cal.
Mr. Garrett P. Serviss	8 Middagh St., Brooklyn, N. Y.
Dr. T. Steele Sheldon, F.R.A.S.	Parkside, Macclesfield, England.
Dr. G. E. Shuey	651 E. Fourteenth St., East Oakland, Cal.
Mr. D. P. Simons	Los Gatos, Cal.
Mr. Francis Sinclair	Care of G. S. Gay, Crafton, San Bernardino Co., Cal.
Mr. Chas. S. Smith*	25 W. 47th St., New York, N. Y.
Mr. Sommers N. Smith	Newport News, Virginia.

Mr. Wm. F. Smith	206 Sansome St., S. F., Cal.
Mr. C. A. Spreckels*	San Mateo, Cal.
Mrs. C. A. Spreckels*	San Mateo, Cal.
Mr. Rudolph Spreckels	2000 Gough St., S. F., Cal.
Miss Gertrude Stanford	1218 Oak St., Oakland, Cal.
Mr. Thos. W. Stanford*	142 Russell St., Melbourne, Victoria.
Dr. Hezekiah Starr	117 Mulberry St., Baltimore, Md.
Mr. John W. Stetson	906 Broadway, Oakland, Cal.
Mr. Robert Stevenson	P. O. Box 2214, S. F., Cal.
Mr. H. F. Stivers	Hunters, Tehama Co., Cal.
Mr. Chauncey M. St. John	U. S. Custom House, S. F., Cal.
Mr. Julius Stone*	Care of The Ohio Central Fuel Co., Columbus, Ohio.
Prof. W. H. von Streeruwitz	P. O. Box 465, Austin, Texas.
Prof. I. Stringham, ph. d.	Berkeley, Cal.
Mlle. Le Brun de Surville	3242 Sacramento St., S. F., Cal.
Mr. Daniel Suter	Room 109, Crocker Building, S. F., Cal.
Hon. A. Sutro*	30 Montgomery Block, S. F., Cal.
Mr. C. F. A. Talbot	204 California St., S. F., Cal.
Mrs. Louis Taussig	2127 California St., S. F., Cal.
Mr. Charles Tousey Taylor	Kamela, Oregon.
Mr. George Taylor	Walnut St., Brookline, Mass.
Dr. Horace H. Taylor	Los Angeles, Cal.
Prof. J. M. Taylor	State University, Seattle, Wash.
Dr. Jesús Muños Tébar	Carácas, Venezuela, S. A.
Mr. John Tebbutt, f.r.a.s.	Observatory, Windsor, New South Wales.
Dr. A. Blair Thaw	Montecito, Santa Barbara Co., Cal.
Mr. I. E. Thayer	28 California St., S. F., Cal.
Dr. John M. Thome*	National Observatory, Cordoba, Argentine Republic.
Mr. D. F. Tillinghast	315 Montgomery St., S. F., Cal.
Mr. S. D. Townley	Astronomical Observatory, Ann Arbor, Michigan.
Mr. John S. Townsend	Stamford Lodge, St. Johns, Seven Oaks, England.
Mr. R. H. Tucker, Jr.	Lick Observatory, Mt. Hamilton, Cal.
Mr. Henry J. Turner*	Woodville, Rappahannock Co., Virginia.
Miss Sara Carr Upton	2109 Pennsylvania Avenue, Washington, D. C.
Mr. Edward H. Van Ingen	9 East 71st St., New York, N.Y.
Rev. Jacob Voorsanger	432 Montgomery St., S. F., Cal.
Mr. W. P. Wallheiser	Bedford, Indiana.
Mr. J. W. Ward	271 Bourke St., Sydney, New South Wales.

Mr. W. R. Warner	Care of Warner & Swasey, East Prospect St., Cleveland, Ohio.
Mrs. W. Seward Webb	680 Fifth Avenue, New York, N. Y.
Prof. Dr. L. Weinek	Imperial Observatory, Prague, Austro-Hungary.
Mr. Chas. J. Welch	1090 Eddy St., S. F., Cal.
President Andrew D. White*	Ithaca, N. Y.
Mrs. Elsie Hadley White	State Normal School, Valley City, North Dakota.
Mr. E. J. White, F.R.A.S.	Observatory, Melbourne, Victoria.
Mr. Ralph Radcliffe-Whitehead	Santa Barbara, Cal.
Mr. A. Stanley Williams, F.R.A.S.	Bella Vista, Hove Park Villas, West Brighton, England.
Mrs. Mary H. Willmarth*	222 Michigan Ave., Chicago, Ill.
Mr. Russell J. Wilson*	2027 California St., S. F., Cal.
Colonel B. Witkovsky*	St. Petersburg, W. O. 9th line, 44. Russia.
Rev. Henry Woods	St. Ignatius College, S F., Cal.
Mr. William Yates	Box 283, Station C, Los Angeles, Cal.
Mr. Frederick W. Zeile*	Room 26, 5th floor, Mills Building, S. F., Cal.
Prof. C. V. Zenger, F.R.A.S.	Smichow, Prague, Bohemia.
Mr. F. R. Ziel	301 California St., S. F., Cal.

LIST OF CORRESPONDING INSTITUTIONS.

Albany, New York, Dudley Observatory.
Allegheny, Pennsylvania, Allegheny Observatory.
Armagh, Ireland, Armagh Observatory.
Berlin, Germany, Redaction des Berliner Jahrbuchs.
Berlin, Germany, Royal Observatory.
Cambridge, England, University Observatory.
Cambridge, Massachusetts, Harvard College Observatory.
Cape Town, Africa, Royal Observatory.
Christiania, Norway, University Observatory.
Cincinnati, Ohio, University Observatory.
Cordoba, Argentine Republic, National Observatory.
Dorpat, Russia, University Observatory.
Dublin, Ireland, Dunsink Observatory.
Dublin, Ireland, Royal Dublin Society.
Edinburgh, Scotland, Royal Observatory.
Geneva, Switzerland, Observatory.
Glasgow, Scotland, University Observatory.
Gotha, Germany, Ducal Observatory.
Goettingen, Germany, Royal Observatory.
Greenwich, England, Royal Observatory.

Hamburg, Germany, Hamburger Sternwarte.
Helsingfors, Russia, University Observatory.
Kasan, Russia, University Observatory.
Kiel, Germany, University Observatory.
Koenigsberg, Germany, University Observatory.
La Plata, Argentine Republic, Observatory.
Leipzig, Germany, University Observatory.
Leyden, Holland, University Observatory.
Lisbon (Tapada), Portugal, Royal Observatory.
London, England, 26 Martin's Lane, British Astronomical Association.
London, England, British Museum.
London, England, Royal Astronomical Society.
London, England, 3 Verulam Bldgs., Gray's Inn, The Nautical Almanac.
Lund, Sweden, University Observatory.
Madison, Wisconsin, Washburn Observatory.
Madras, India, Observatory.
Madrid, Spain, Royal Observatory.
Marseilles, France, Observatory.
Melbourne, Victoria, Observatory.
Mexico, Mexico, Sociedad Cientifica "Antonio Alzate."
Milan, Italy, Royal Observatory.
Moscow, Russia, University Observatory.
Munich, Germany, Royal Observatory.
Naples, Italy, Royal Observatory.
New Haven, Connecticut, Yale University Observatory.
New York, New York, American Mathematical Society.
New York, New York, Columbia University Observatory.
Nice, France, Observatory.
Northfield, Minnesota, Carleton College Observatory.
Oxford, England, Radcliffe Observatory.
Oxford, England, University Observatory.
Paris, France, Bureau of Longitudes.
Paris, France, National Observatory.
Potsdam, Germany, Astrophysical Observatory.
Prague, Austro-Hungary, University Observatory.
Pulkowa, Russia, Imperial Observatory.
Rio de Janeiro, Brazil, Observatory.
Rome, Italy, Observatory of the Roman College.
Rome, Italy, Italian Spectroscopic Society.
Rome, Italy, Specula Vaticana.
San Francisco, California, California Academy of Sciences.
San Francisco, California, Technical Society of the Pacific Coast.
Stockholm, Sweden, University Observatory.
Strassburg, Germany, University Observatory.
Sydney, New South Wales, Observatory.
Tacubaya, Mexico, National Observatory.
Tokio, Japan, University Observatory.
Toronto, Canada, Astronomical and Physical Society of Toronto.
Toulouse, France, Observatory.

Turin, Italy, Observatory.
University Park, Colorado, Chamberlin Observatory.
University of Virginia, Virginia, McCormick Observatory.
Upsala, Sweden, University Observatory.
Vienna, Austria, Imperial Observatory.
Vienna (Ottakring), Austria, Von Kuffner's Observatory.
Washington, District of Columbia, Library of Congress.
Washington, District of Columbia, National Academy of Sciences.
Washington, District of Columbia, Naval Observatory.
Washington, District of Columbia, Smithsonian Institution.
Washington, District of Columbia, The American Ephemeris.
Washington, District of Columbia, U. S. Coast and Geodetic Survey.
William's Bay, Wisconsin, Yerkes Observatory.
Zurich, Switzerland, Observatory.

EXCHANGES.

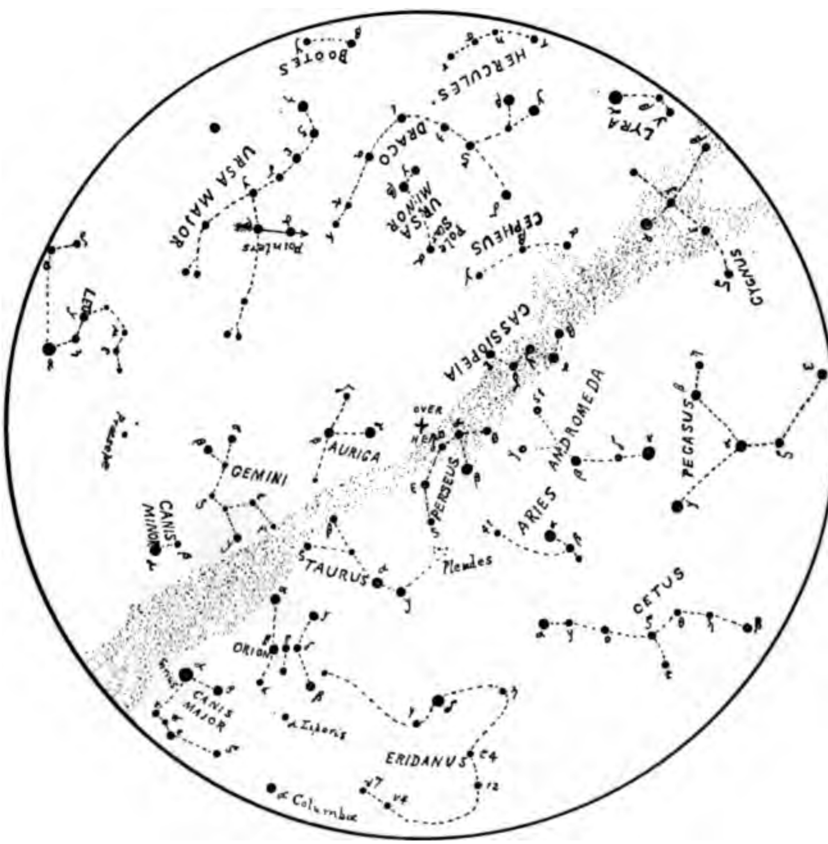
Astrophysical Journal, William's Bay, Wisconsin.
Sirius, Cologne, Germany.
The Observatory, Greenwich, England.

FOR REVIEW.

[See *Publications* A. S. P., Vol. VIII, p. 101.]

The Call, San Francisco, California.
The Chronicle, San Francisco, California.
The Examiner, San Francisco, California.
The Mercury, San José, California.
The Overland Monthly, San Francisco, California.
The Record-Union, Sacramento, California.
The Times, Los Angeles, California.
The Tribune, Oakland, California.

MAP I.



The sky on November 22, at 12 o'clock.
December 6, at 11 o'clock.
December 21, at 10 o'clock.
January 5, at 9 o'clock.
January 20, at 8 o'clock.

A SERIES OF SIX STAR MAPS.

The star maps in this series have been drawn, using those in PROCTOR'S "*Half Hours with the Stars*" as a basis. The scale has been somewhat reduced, in order to accommodate a map to a page of the Society's *Publications.*

The making of these maps was originally undertaken by Professor D. A. LEHMAN, at Professor HOLDEN'S suggestion. A portion of them remained unfinished at the time of Professor LEHMAN'S departure from the Lick Observatory, in July, 1897, and these I have completed.

The maps were originally adapted to a north latitude of about 52°, so that, for the latitudes of the United States, they will be somewhat in error, but not so much, however, as to cause serious inconvenience. Under each map will be found the date and time at which the sky will be as represented in the accompanying map; *e. g.* Map No. 1 shows the sky as it appears on November 22d at midnight, December 5th at 11 o'clock, December 21st at 10 o'clock, January 5th at 9 o'clock, and January 20th at 8 o'clock. It is presumed that the maps will be used for observations principally between the hours of 8 o'clock in the evening and midnight. It should be borne in mind, however, that the same map represents the aspect of the constellations on other dates than those given, but at a *different hour* of the night. Map No. 1, which we have been considering, shows the sky's aspect on October 23d at 2 A. M., September 23d at 4 A. M., and also on February 20th at 6 P. M., as well as on the dates and at the hours given in the map. The same is true of all the other maps in the series. For any date *between* those given, the map will represent the sky at a time *between* the hours given; for instance, on November 26th, Map No. 1 will represent the sky at 11:45 o'clock, on November 30th at 11:30 o'clock, and on December 2d at 11:15 o'clock.

If the maps are held with the center exactly overhead and the *top* pointing to the north, the lower part of the map will be south, the right-hand portion will be to the west, and the left-hand to the east, the circle bounding the map representing the horizon. It will be seen from this that each map shows the *whole* of the sky visible at these times.

It will be noted that a number of the constellations about the pole never set, but are always visible in some part of the northern

sky. As the maps are the projections of a curved surface upon a plane, there is, of course, considerable distortion, but this will hardly be confusing.

The names of the *constellations* are inserted in capitals to distinguish them, while the names of *stars* and other data are in small letters.

The planets are continually changing their places, and hence are not inserted on the maps which represent the *stars* for one year as well as another.

From the *Planetary Notes* it can readily be told if the brighter planets — *Venus*, *Jupiter*, and *Mars* (when at his brightest) — are visible, and in what part of the sky. *Saturn* can almost always be told by its steady yellowish light. If it is desired to locate a planet accurately, a star map giving circles of Right Ascension and parallels of Declination should be used, and the place of the planet ascertained from the tables accompanying the *Planetary Notes* in these *Publications* or from any of the nautical almanacs. It may assist in identifying a planet, to remember that the planets do not depart widely, north or south, from the Sun's path — the ecliptic. C. D. PERRINE.

MT. HAMILTON, January 7, 1898.

PLANETARY PHENOMENA FOR MARCH AND APRIL, 1898.

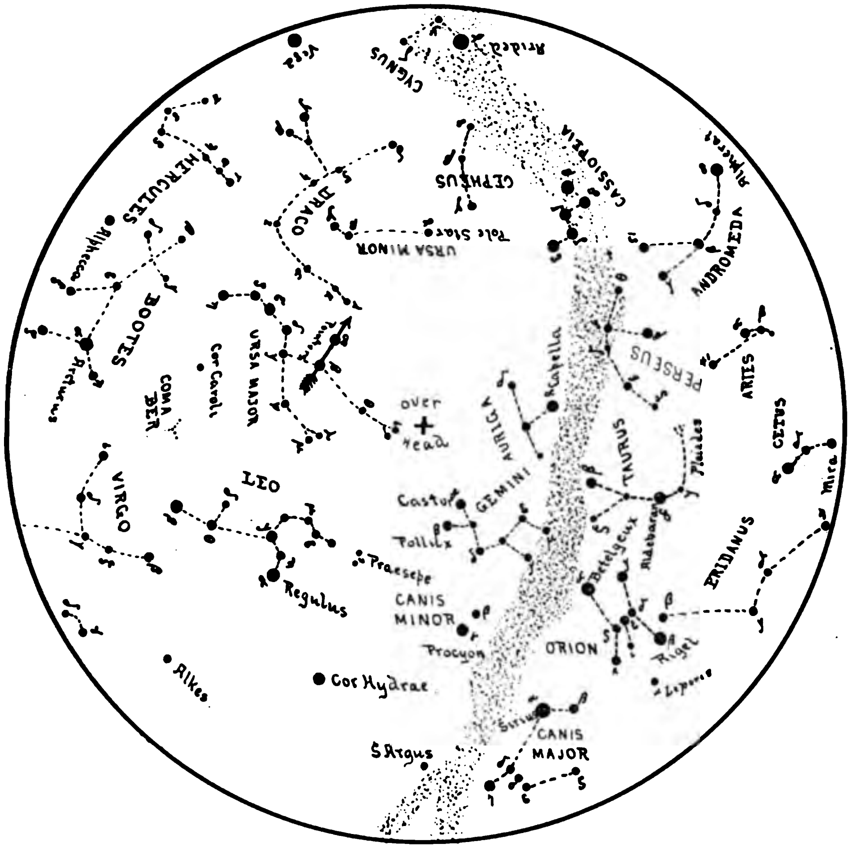
BY PROFESSOR MALCOLM MCNEILL.

MARCH.

The Sun reaches the vernal equinox and crosses the equator from south to north on the morning of March 20th, at 6 o'clock, P. S. T.

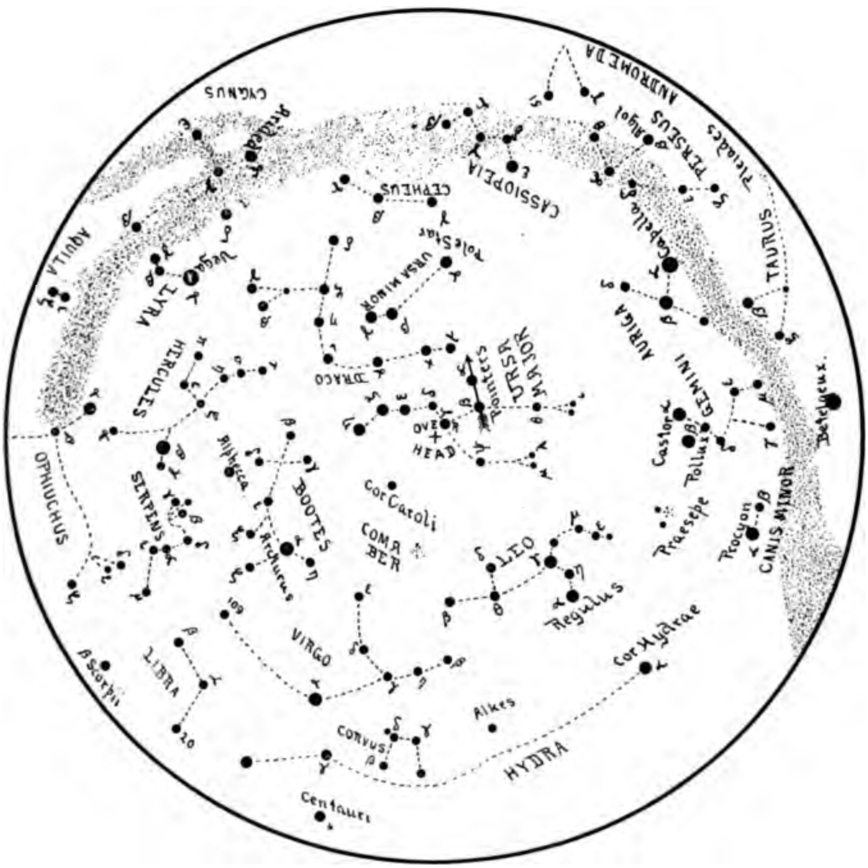
Mercury is too near the Sun to be easily seen until near the close of the month. It is a morning star until March 16th, when it passes superior conjunction and becomes an evening star. It moves rapidly away from the Sun, and by the end of the month sets about an hour and a quarter after sunset. It is quite near *Venus* near the close of the month, and passes that planet about two diameters of the Moon to the north on March 26th. The two planets will not be far apart during the last ten days of the month.

MAP II



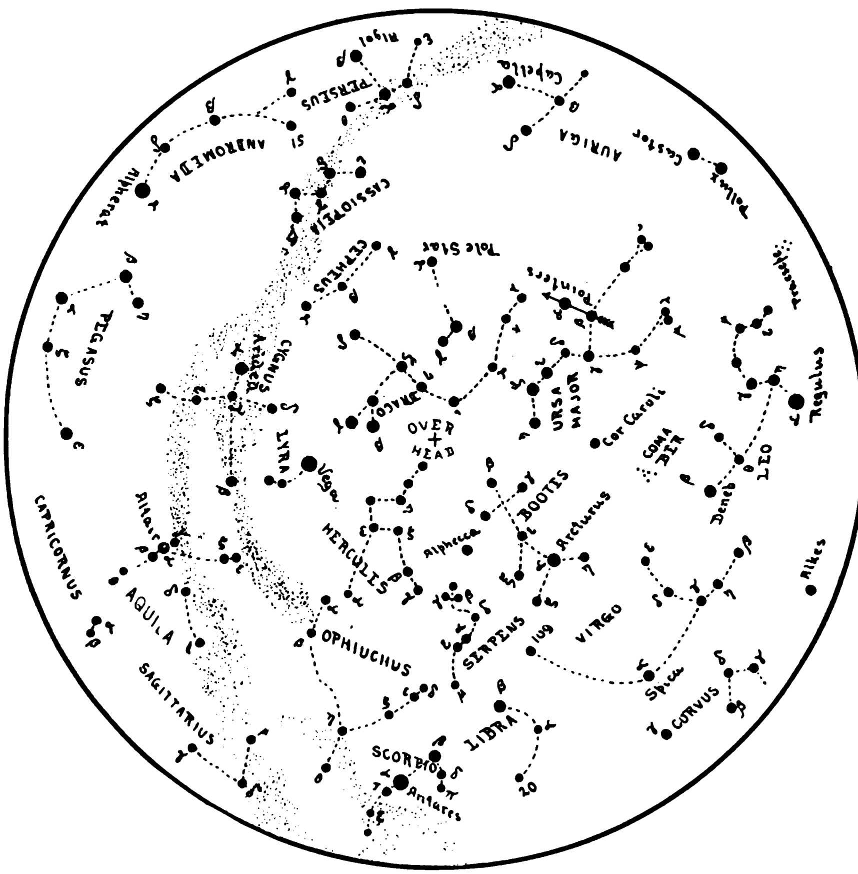
The sky on January 20, at 12 o'clock.
February 4, at 11 o'clock.
February 19, at 10 o'clock.
March 6, at 9 o'clock.
March 21, at 8 o'clock.

MAP III



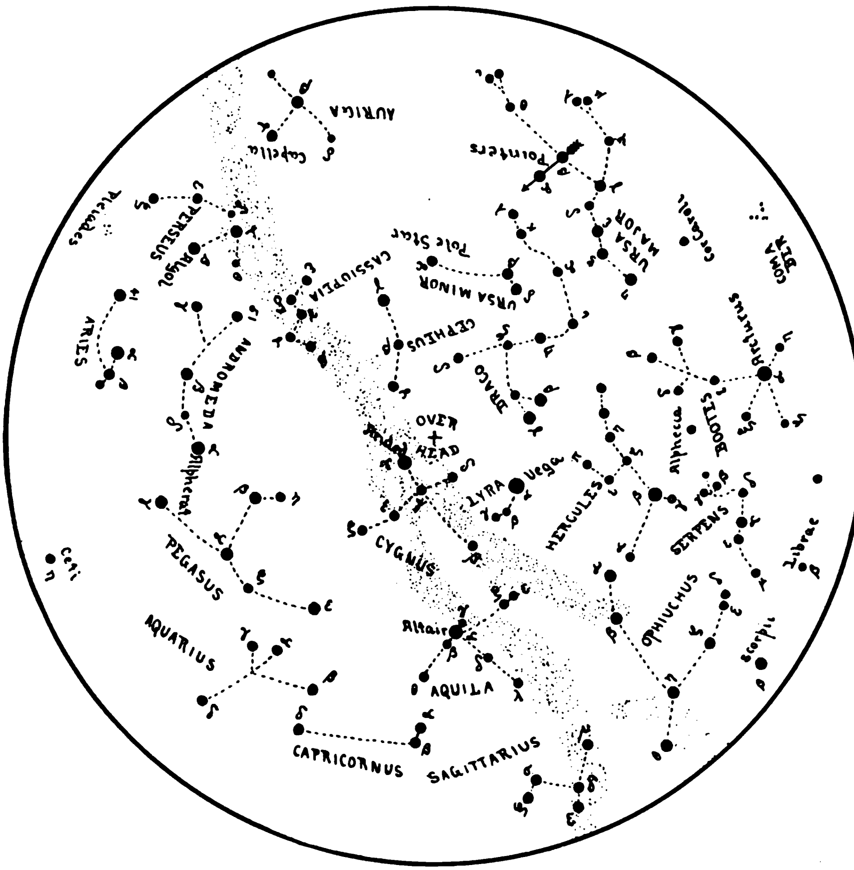
The sky on	March	21,	at 12	o'clock.
	April	5,	at 11	o'clock.
	April	20,	at 10	o'clock.
	May	5,	at 9	o'clock.
	May	21,	at 8	o'clock.

MAP IV



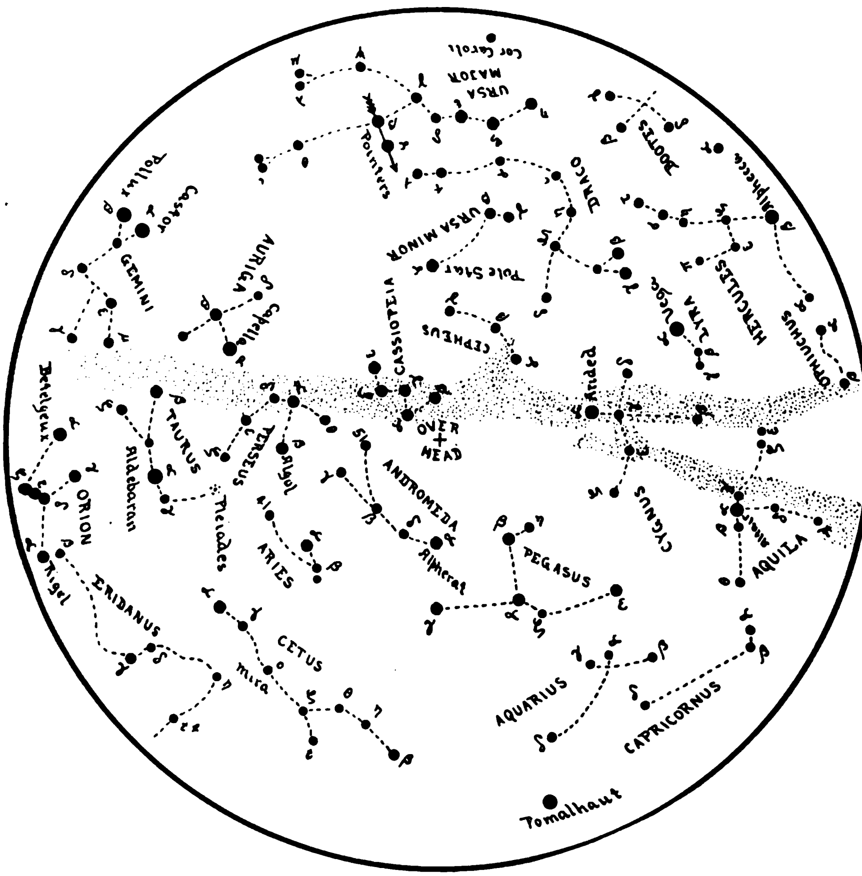
The sky on May 21, at 12 o'clock.
June 5, at 11 o'clock.
June 21, at 10 o'clock.
July 7, at 9 o'clock.
July 22, at 8 o'clock.

MAP V



The sky on July 22, at 12 o'clock.
August 7, at 11 o'clock.
August 23, at 10 o'clock.
September 8, at 9 o'clock.
September 23, at 8 o'clock.

MAP VI



The sky on September 23, at 12 o'clock.
October 8, at 11 o'clock.
October 23, at 10 o'clock.
November 7, at 9 o'clock.
November 22, at 8 o'clock.

Venus is also an evening star near the Sun, too near to be easily seen until after the middle of the month.

Mars is a morning star, rising about an hour before sunrise. It has begun to approach the Earth, but will not be near enough until autumn to be at all conspicuous.

Jupiter is in good position for observation, and is above the horizon during nearly the entire night. It comes to opposition with the Sun on March 25th. It retrogrades (moves westward), about three degrees in the western part of the constellation *Virgo*, and at the beginning of the month it is about one degree south and west of the third magnitude star γ *Virginis*.

Saturn rises earlier than during February, but is not high enough to be easily seen until some time after midnight. It is in quadrature with the Sun, that is six hours behind it, on March 2d. It is nearly stationary, moving very slowly eastward until March 21st, and then a little westward in the constellation *Scorpio*, north and east of the first magnitude star *Antares*, α *Scorpii*, and about eight degrees distant from it. The minor axis of the rings is a little less than the polar diameter of the planet.

Uranus precedes *Saturn* about half an hour, and is about two degrees east and one degree south of the third magnitude star β *Scorpii.*

Neptune is in the eastern part of *Taurus*.

April.

Mercury comes to greatest eastern elongation on April 10th, and then sets nearly an hour and three quarters after sunset. It will be far enough away from the Sun to be easily seen in the evening twilight until the last week of the month. April is, for this year, the best month for seeing *Mercury* as an evening star. Toward the close of the month it rapidly approaches the Sun, and comes to inferior conjunction on the morning of May 1st.

Venus is also an evening star, somewhat farther from the Sun than it was in March. It is in the same region as *Mercury*, somewhat to the west of it, until April 18th, when the planets are in conjunction again, with *Mercury* three degrees to the north. Their distance apart increases rapidly after this.

Mars rises a little earlier in the morning; by the end of the month about an hour and a half before the Sun. It increases its apparent distance from the Sun about five degrees during the month. On April 30th it passes perihelion.

Jupiter is still in fine position for observation, rather better for evening observation than it was during March, as it is well above the horizon at sunset. It moves westward about three degrees in the constellation *Virgo*, and during the middle of the month is very near the fourth magnitude star η *Virginis*. On April 12th, the time of nearest approach, the planet is only about half of the Moon's diameter north of the star.

Saturn rises earlier—by the end of the month at a little after 9 o'clock. It is in the constellation *Scorpio*, and moves about one degree westward. The rings are about as in March.

Uranus precedes *Saturn* about half an hour and moves about the same amount westward. By the end of the month it is about one degree south and east of the third magnitude star β *Scorpii*.

Neptune is in the eastern part of *Taurus*.

Explanation of the Tables.

The phases of the Moon are given in Pacific Standard time. In the tables for Sun and planets, the second and third columns give the Right Ascension and Declination for Greenwich noon. The fifth column gives the local mean time for transit over the Greenwich meridian. To find the local mean time of transit for any other meridian, the time given in the table must be corrected by adding or subtracting the change per day, multiplied by the fraction whose numerator is the longitude from Greenwich in hours, and whose denominator is 24. This correction is seldom much more than 1^m. To find the standard time for the phenomenon, correct the local mean time by *adding* the difference between standard and local time if the place is west of the standard meridian, and *subtracting* if east. The same rules apply to the fourth and sixth columns, which give the local mean times of rising and setting for the meridian of Greenwich. They are roughly computed for Lat. 40°, with the noon Declination and time of meridian transit, and are intended as only a rough guide. They may be in error by a minute or two for the given latitude, and for latitudes differing much from 40° they may be several minutes out.

Phases of the Moon, P. S. T.

			H. M.
Full Moon,	Mar.	8,	1 29 A. M.
Last Quarter,	Mar.	14,	11 48 P. M.
New Moon,	Mar.	22,	12 37 A. M.
First Quarter,	Mar.	29,	11 40 P. M.

THE SUN.

1898.	R. A. H. M.	Declination. ° ′	Rises. H. M.	Transits. H. M.	Sets. H. M.
Mar. 1.	22 50	− 7 28	6 37 A.M.	12 12 P.M.	5 47 P.M.
11.	23 27	− 3 35	6 22	12 10	5 58
21.	0 3	+ 0 22	6 6	12 7	6 8
31.	0 40	+ 4 17	5 50	12 4	6 18

MERCURY.

Mar. 1.	22 5	− 14 5	6 16 A.M.	11 28 A.M.	4 38 P.M.
11.	23 12	− 7 13	6 19	11 55	5 31
21.	0 22	+ 1 34	6 21	12 26 P.M.	6 31
31.	1 33	+ 10 48	6 20	12 57	7 34

VENUS.

Mar. 1.	23 4	− 7 31	6 53 A.M.	12 27 P.M.	6 1 P.M.
11.	23 50	− 2 33	6 43	12 34	6 25
21.	0 36	+ 2 33	6 31	12 40	6 49
31.	1 21	+ 7 34	6 20	12 46	7 12

MARS.

Mar. 1.	21 10	− 17 30	5 33 A.M.	10 32 A.M.	3 31 P.M.
11.	21 41	− 15 8	5 16	10 24	3 32
21.	22 11	− 12 31	4 58	10 15	3 32
31.	22 40	− 9 42	4 38	10 5	3 32

JUPITER.

Mar. 1.	12 33	− 1 52	8 5 P.M.	1 58 A.M.	7 51 A.M.
11.	12 29	− 1 25	7 19	1 14	7 9
21.	12 24	− 0 54	6 33	12 30	6 27
31.	12 20	− 0 24	5 43	11 42 P.M.	5 41

SATURN.

Mar. 1.	16 43	− 20 26	1 19 A.M.	6 6 A.M.	10 53 A.M.
11.	16 44	− 20 27	12 41	5 28	10 15
21.	16 44	− 20 26	12 2	4 49	9 36
31.	16 44	− 20 24	11 23 P.M.	4 10	8 57

URANUS.

Mar. 1.	16 6	− 20 42	12 44 A.M.	5 30 A.M.	10 16 A.M.
11.	16 6	− 20 42	12 5	4 51	9 37
21.	16 6	− 20 41	11 25 P.M.	4 11	8 57
31.	16 5	− 20 40	10 45	3 31	8 17

Neptune.

1898.	R. A. H. M.	Declination. ° ′	Rises. H. M.	Transits. H. M.	Sets. H. M.
Mar. 1.	5 16	+21 43	11 19 A.M.	6 37 P.M.	1 55 A.M.
11.	5 16	+21 43	10 40	5 58	1 16
21.	5 16	+21 44	10 1	5 19	12 37
31.	5 17	+21 45	9 22	4 40	11 58 P.M.

Eclipses of *Jupiter's* Satellites, P. S. T.

(Off left-hand limb, as seen in an inverting telescope before opposition, March 25th, afterward off right.)

		H. M.			H. M.
III, D,	Mar. 6.	1 56 A. M.	I, D,	Mar. 16.	6 33 P. M.
I, D,	6.	3 42 A. M.	I, D,	22.	1 58 A. M.
II, D,	7.	9 38 P. M.	II, D,	22.	2 51 A. M.
I, D,	7.	10 11 P. M.	I, D,	23.	8 26 P. M.
I, D,	13.	5 36 A. M.	II, D,	25.	4 10 P. M.
III, D,	13.	5 55 A. M.	II, R,	25.	6 40 P. M.
I, D,	15.	12 5 A. M.	III, R,	27.	4 28 P. M.
II, D,	15.	12 15 A. M.	I, R,	31.	3 30 A. M.

Phases of the Moon, P. S. T.

		H. M.
Full Moon,	Apr. 6,	1 20 P. M.
Last Quarter,	Apr. 13,	6 28 A. M.
New Moon,	Apr. 20,	2 21 P. M.
First Quarter,	Apr. 28,	6 5 P. M.

The Sun.

1898.	R. A. H. M.	Declination. ° ′	Rises. H. M.	Transits. H. M.	Sets. H. M.
Apr. 1.	0 43	+ 4 40	5 48 A.M.	12 4 P.M.	6 20 P.M.
11.	1 20	+ 8 26	5 32	12 1	6 30
21.	1 57	+11 58	5 18	11 59 A.M.	6 40
May 1.	2 35	+15 10	5 4	11 57	6 50

Mercury.

Apr. 1.	1 39	+11 38	6 20 A.M.	1 0 P.M.	7 40 P.M.
11.	2 31	+17 45	6 12	1 12	8 14
21.	2 48	+19 0	5 42	12 49	7 56
May 1.	2 34	+15 41	5 2	11 56 A.M.	6 50

Venus.

Apr. 1.	1 26	+ 8 4	6 19 A.M.	12 46 P.M.	7 13 P.M.
11.	2 12	+12 45	6 9	12 53	7 37
21.	3 0	+16 56	6 3	1 2	8 1
May 1.	3 50	+20 24	6 0	1 12	8 24

Mars.

1898.	R. A. H. M.	Declination. ° ′	Rises. H. M.	Transits. H. M.	Sets. H. M.
Apr. 1.	22 43	− 9 24	4 36 A.M.	10 4 A.M.	3 32 P.M.
11.	23 12	− 6 26	4 16	9 54	3 32
21.	23 41	− 3 23	3 54	9 43	3 32
May 1.	0 9	− 0 18	3 33	9 32	3 31

Jupiter.

Apr. 1.	12 19	− 0 21	5 40 P.M.	11 38 P.M.	5 38 A.M.
11.	12 15	+ 0 8	4 54	10 54	4 54
21.	12 11	+ 0 33	4 9	10 11	4 13
May 1.	12 7	+ 0 52	3 25	9 28	3 31

Saturn.

Apr. 1.	16 44	− 20 24	11 19 P.M.	4 6 A.M.	8 53 A.M.
11.	16 43	− 20 21	10 38	3 25	8 12
21.	16 41	− 20 17	9 56	2 44	7 32
May 1.	16 39	− 20 12	9 15	2 3	6 51

Uranus.

Apr. 1.	16 6	− 20 39	10 40 P.M.	3 27 A.M.	8 14 A.M.
11.	16 4	− 20 37	10 0	2 47	7 34
21.	16 3	− 20 33	9 19	2 6	6 53
May 1.	16 1	− 20 29	8 38	1 25	6 12

Neptune.

Apr. 1.	5 17	+ 21 45	9 19 A.M.	4 37 P.M.	11 55 P.M.
11.	5 18	+ 21 47	8 40	3 58	11 16
21.	5 19	+ 21 48	8 2	3 20	10 38
May 1.	5 20	+ 21 50	7 24	2 42	10 0

Eclipses of *Jupiter's* Satellites, P. S. T.

(Off right hand limb, as seen in an inverting telescope.)

		H. M.			H. M.
I, R,	Apr. 1.	6 59 P. M.	I, R,	Apr. 14.	4 18 A. M.
II, R,	1.	9 17 P. M.	I, R,	15.	10 47 P. M.
III, R,	3.	8 25 P. M.	II, R,	16.	2 30 A. M.
I, R,	7.	2 24 A. M.	I, R,	17.	5 15 P. M.
I, R,	8.	8 53 P. M.	I, R,	23.	12 41 A. M.
II, R,	8.	11 53 P. M.	I, R,	24.	7 9 P. M.
III, R,	11.	12 22 A. M.	II, R,	26.	6 24 P. M.

(TWENTY-EIGHTH) AWARD OF THE DONOHOE COMET-MEDAL.

The Comet-Medal of the Astronomical Society of the Pacific has been awarded to C. D. PERRINE, Assistant Astronomer in the Lick Observatory, for his discovery of an unexpected comet on October 16, 1897.

The Committee on the Comet-Medal,

EDWARD S. HOLDEN.
J. M. SCHAEBERLE.

December 16, 1897.

ASTRONOMICAL OBSERVATIONS IN 1897.

Made by TORVALD KÖHL, at Odder, Denmark.

VARIABLE STARS.

*Z Cygni.**

January	1:	Z invisible.
	2:	id.
February	3:	id.
	4:	id.
	24:	= e.
	27:	id.
April	19:	= a.
	29:	> a. < 26.
May	23:	= b.
August	22:	invisible.
September	11:	id.
	25:	< e.
	27:	id.
October	20:	id.
	25:	id.
November	8:	id.
	11:	a little < d.
	14:	> d. < c.
December	13:	a little > a.
	18:	= a.
	19:	id.

The Stars A and B, near X^2 Cygni.†

January	1:	A > B.
	2:	A = B.
February	4:	id.
April	29:	id.
May	23:	id.
September	14:	A > B.
	27:	A < B.
October	20:	id.
	25:	id.
November	8:	A = B.
	11:	A < B.
December	19:	A < B.

The star A is reddish.

---

* *Vide* the sketch in the *Publications* A. S. P., No. 48, page 69.

† *Vide* the sketch in the *Publications* A. S. P., No. 34, page 37, and the observations in No. 48, page 71.

S Ursæ majoris.

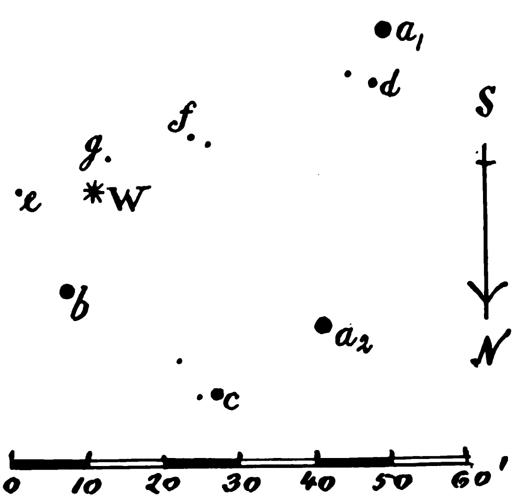
January	2:	$\left\{\begin{array}{l} < \text{d.} \\ > \text{e.} \end{array}\right.$
	27:	id.
February	4:	$\left\{\begin{array}{l} < \text{c.} \\ > \text{d.} \end{array}\right.$
	24:	= d.
	27:	id.
March	31:	$\left\{\begin{array}{l} < \text{e.} \\ > \text{f.} \end{array}\right.$
April	19:	= g.
	29:	invisible.
May	23:	id.
August	27:	= d.
September	11:	$\left\{\begin{array}{l} > \text{d.} \\ < \text{c.} \end{array}\right.$
	14:	id.
	18:	a little > d.
	25:	id.
	27:	id.
October	20:	a little < e.
	25:	< e.
November	11:	= f.
	14:	id.
December	13:	< g.
	18:	id.

T Ursæ majoris.

The star was invisible on all the dates on which *S Ursæ majoris* was watched, with the exception of the following dates:—

March	31:	T < g.
April	19:	$\left\{\begin{array}{l} > \text{f.} \\ < \text{e.} \end{array}\right.$
May	23:	a little > b.
August	27:	= g.

W Pegasi [a_1 a little > a_2].



The Region about *W Pegasi.*

August	22:	W $\left\{\begin{array}{l} < \text{b.} \\ > \text{c.} \end{array}\right.$
	23:	a little < b.
September	18:	< b.
October	20:	a little < c.
	21:	id.
	25:	id.
	26:	id.
November	14:	< c.
December	13:	$\left\{\begin{array}{l} < \text{f.} \\ = \text{g.} \end{array}\right.$
	18:	id.
	19:	a little < g.

14 and 16 Comæ Berenicis.

For many years I have perceived a slight variation in the stars *14* and *16 Comæ*, namely:—

1879,	March	20:	14 > 16.	1895,	March	2:	14 > 16.
1880,	January	19:	id.		November	27:	14 < 16.
	March	8:	id.		December	11:	14 = 16.
	December	9:	14 = 16.	1896,	March	4:	14 < 16.
1881,	March	28:	14 > 16.			11:	14 = 16.
	April	18:	14 = 16.			17:	id.
1882,	January	14:	14 > 16.			31:	14 > 16.
	February	21:	id.		May	1:	14 = 16.
	November	19:	id.			4:	id.
1885,	April	12:	id.			9:	id.
1887,	March	16:	id.	1897,	January	2:	14 = 16.
1891,	March	9:	id.		February	24:	id.
1893,	April	5:	id.			27:	id.
1894,	March	28:	14 < 16.		March	31:	id.
	April	8:	14 = 16.		April	19:	14 < 16.
					December	19:	14 = 16.

12 and 13 Comæ Berenicis.

These two stars also seem to have a slight variation in brightness.

1894,	March	28:	13 = 12.		May	9:	13 < 12.
	April	8:	13 < 12.	1897,	January	2:	13 = 12.
1895,	March	2:	13 = 12.		February	24:	13 < 12.
	December	11:	13 > 12.			27:	id.
1896,	March	17:	13 = 12.		March	31:	id.
	May	1:	13 < 12.		April	19:	id.
		4:	13 = 12.		December	19:	id.

Besides the above-mentioned observations, a great many other sketches of fixed stars have been made with reference to supposed variations.

FIREBALLS.

In the past year twelve fireballs have been seen from stations in Denmark.

No.		Time.	Beginning.	End.	Mag.	Station.	Note.
1	January	26, 9^h 12^m P. M.	$272° + 55°$	$238° + 35°$	¼ ☾	Stevns.	Explosion.
2	April	19, 8 15 P. M.	30° alt. SE.	10° alt. NE.	☾	Lögten.	Train.
3	May	17, 10 26 P. M.	SW.	$254° + 12°$	♀	Copenhagen.	Train.
4	July	27, 9 13 P. M.	30° alt. NW.	40° alt. SSE.	*	Nestved.	Red.
5		31, 10 50 P. M.	$220° + 13°$	$208° + 14°$	*	Copenhagen.	
6	October	15, 5 50 P. M.	NE.	45° alt. SW.	♀	Hilleröd.	
7		20, 12 20 A. M.		NW.	☾	Odder.	Near the horizon.
8		20, 7 11 P. M.	NW.		*	Copenhagen.	
9		21, 7 57 P. M.	$270° + 30°$	$264° + 10°$	*	Odder.	
10	November	25, 6 28 P. M.	$191° + 40°$	$120° + 30°$	♃	Svendborg.	Train.
			30° azimuth	15° azimuth			
			W. from N.	E. from N.	♃	Copenhagen.	Train.
			20° altitude.	14° altitude.			
11		25, 11 50 P. M.		SSE.	¼ ☾	Samsö.	Blue. Explosion.
12	December	21, 5 15 P. M.	Zenith.	E.	☾	Fanö.	Train.

The little observatory in the garden of the Real School at Odder has been altered in the past year, so that the dome which formerly could be opened in six directions can now be turned around.

FIRST AWARD OF THE BRUCE MEDAL.

The award for 1898 of the BRUCE Medal of the Astronomical Society of the Pacific has been made to Professor SIMON NEWCOMB.

SPECTROSCOPIC BINARY STARS.

BY R. G. AITKEN.

The announcement made in Harvard College Observatory *Circular*, No. 21, that *β Lupi* is a spectroscopic binary, calls new attention to one of the most interesting classes of stars known. Binary star systems—that is, systems comprising two suns in orbital motion about a common center of gravity—have been known since the time of HERSCHEL; but their periods of revolution are reckoned in years and even in centuries. The most rapid binary known at the beginning of the present decade needed eleven and a half years to complete a single revolution. Small wonder then, that the startling announcements made by PICKERING and VOGEL that *ζ Ursæ majoris* made a complete revolution in about 105 (later reduced to 52) days, and that *β Persei (Algol), β Aurigæ*, and *α Virginis* had periods of from 2.9 to 4 days, should be received with caution and even with suspicion.

It is true, indeed, that GOODRICKE, who discovered the variable character of the light of *Algol* in 1782, suggested an eclipse of the visible star by a dark body as a plausible explanation of the periodic dimming of its light. But another explanation that found favor was, that *Algol* was a bright star, upon whose photosphere spots analogous to our sun-spots were irregularly distributed, the periodic time of light variation corresponding to the time of axial rotation. At best, GOODRICKE'S hypothesis was classed with other theories, convenient as explanations, but not susceptible of proof. The modern spectroscope, however, by demonstrating that the spectrum of the star was sensibly the

same in quality in all its light phases, disposed of the spot theory; and later, in the skillful hands of VOGEL, proved that GOODRICKE's hypothesis was substantially correct.

Professor VOGEL photographed the spectrum of *Algol* on many nights, and on each plate photographed also the spectrum of hydrogen. If the star were at rest relatively to the Earth, the hydrogen lines in the star's spectrum should correspond to those in the artificial spectrum. If the star were receding from the Earth, the lines in its spectrum (according to DOPPLER's principle) should be shifted slightly, with respect to the lines in the hydrogen spectrum, toward the red end, and if approaching the Earth, toward the violet end of the spectrum. Now, VOGEL found that before the obscuration the lines were shifted toward the red end by an amount corresponding to a velocity of recession of about twenty-seven miles a second. After obscuration, the shifting of the lines towards the violet end indicated a somewhat greater velocity of approach. This is just what should happen if a dark body were swinging the bright star around a common center of gravity in an orbit nearly edgewise to the Earth, the whole system meanwhile approaching the Sun.

VOGEL's results were published in November, 1889. In August of the same year, Professor E. C. PICKERING announced that certain lines in the photographic spectrum of ζ *Ursæ majoris (Mizar)* were found to be double on some plates, single on others. Examination of many plates showed a periodic recurrence of the phenomenon at intervals of about fifty-two days. A little later in the same year, he announced that Miss A. C. MAURY had discovered the same peculiarity in the spectrum of β *Aurigæ*, with the important difference that in the latter star the doubling of the lines occurred at intervals slightly less than two days. The explanation of this phenomenon is, that these stars consist of two components revolving, as in the case of *Algol*, in an orbit turned nearly edgewise to us, each component being bright. When the stars are at right angles to the line of vision (at elongation, that is), one will be moving towards us, the other away from us, and the lines in their spectra are, consequently, shifted in opposite directions. As the stars are so close together that their spectra overlie each other on the plate, the effect is to show the lines in the resulting compound spectrum apparently double.

In April, 1890, VOGEL published his investigations on the spectrum of α *Virginis*. Discordances in the values of the

velocity of the star in the line of sight led to more extended observations, with the result that it was found that the star is moving in a nearly circular orbit, with a period of about four days. As the lines in the spectrum show no evidence of doubling, the companion must be relatively a dark star, as in the case of *Algol.* But as the bright star suffers no diminution in its light, the orbit must be sufficiently inclined to the line of sight to prevent eclipses.

These stars, then, are typical of the three varieties of binary systems whose existence has been demonstrated by the spectroscope, viz. (1) a bright star with a relatively dark companion, the plane of the orbit passing so nearly through the Sun that the brighter star suffers periodic partial or total eclipse; (2) a bright star with a relatively dark companion, the plane of the orbit being so inclined to the line of vision that eclipses are impossible; (3) a system of two bright stars. It is probable that stars of the η *Aquilæ* type—to which attention is called in a note elsewhere in this number — should be included in the second class. Perhaps, too, that puzzling variable, β *Lyræ*, — a variable *sui generis*, one writer calls it—should be included, as PICKERING (H. C. O. Circular 7) classes it with the *Algol*-type variables. Since this observer's discovery of the composite nature of its spectrum, β *Lyræ* has been carefully studied by many observers, and important papers on its photographic spectrum have been published by BELOPOLSKY, VOGEL, SIDGREAVES, LOCKYER, and others. To indicate, even in the briefest manner, the complex nature of the observed phenomena and the various hypotheses that have been framed to account for them, would require a separate article. As it is the purpose of the present paper merely to give some account of our knowledge of the three varieties of binaries above enumerated, it must suffice here to say of β *Lyræ* that, while it is probably binary, no hypothesis has yet been framed that explains completely all the observed changes in light and spectrum.

When VOGEL made public his researches on β *Persei*, ten *Algol*-type variable stars were known. Since then, their number has been increased to fifteen, possibly sixteen. They are here given, together with their discoverers, dates of discovery, approximate periods, range of magnitude, and duration of change. The data are nearly all taken from CHANDLER'S "Third Catalogue of Variable Stars."

NAME.	DISCOVERER.		PERIOD.	MAGNITUDE AND DURATION OF CHANGE.
β Persei (Algol) .	Goodricke,*	1782	$2^d\ 20^h\ 48^m\ 55^s$	2.3 to 3.5 in 10^h
S Cancri	Hind,	1848	9 11 37 45	8.2 to 9.8 in 21½
λ Tauri	Baxendall,	1848	3 22 52.2	3.4 to 4.2 in 10
δ Libræ	Schmidt,	1859	2 7 51 23	5.0 to 6.2 in 12
U Coronæ	Winnecke,	1869	3 10 51 12	7.5 to 8.9 in 10 nearly
U Cephei	Ceraski,	1880	2 11 49 38	7.1 to 9.2 in 10
U Ophiuchi . . .	Sawyer,	1881	0 20 7 43	6.0 to 6.7 in 5
Y Cygni	Chandler,	1886	1 11 57 28	7.1 to 7.9 in about 8
R Canis Majoris .	Sawyer,	1887	1 3 15 46	5.9 to 6.7 in 5
S Antliæ † . . .	Paul,	1888	0 7 46 48	6.7 to 7.3 in about 3½
Z Herculis . . .	Müller & Kempf,	1891	3 23 49.54	7.1 to 8.0
R Aræ	Roberts,	1891	4 10 12.7	6.9 to 8.0 in 10.3
RS Sagittarii . .	Gould,	1874	2 9 58.6	6.4 to 7.5
S Velorum . . .	Woods,	1894	5 22 24.35	7.8 to 9.3 in 15.2
Y Bootis (?) ‡ . .	Parkhurst,	1894	2.6	8.0 to 8.6
W Delphini . . .	Miss Wells,	1895	4 19 21.2	9.5 to $<$ 12 in 3 $\pm$

The eclipse hypothesis was naturally applied to these *Algol*-type stars, but not with immediate and complete success. In the case of *Algol* itself a difficulty was encountered, in that the period was known to be about six seconds shorter than at the time of GOODRICKE's discovery, while in 1798, and again in 1830, it was slightly longer. The irregularities in the periods of other stars, as, for instance, *S Cancri* and *λ Tauri*, were even more marked; in fact, it is even now impossible to determine the law governing the inequalities of the last-named star.

Dr. CHANDLER (A. J. VII) had investigated the irregularities in *Algol's* period fully; and in 1892 he followed this investigation with the demonstration of a proposition that may be put most briefly in his own words:—

"*Algol,* together with the close companion — whose revolution in $2^d\ 20^h.8$ produces by eclipse the observed fluctuations in light, according to the well-known hypothesis of GOODRICKE, confirmed by the elegant investigation of VOGEL, — is subject to still another orbital motion of a quite different kind. Both have a common revolution about a third body, a large, distant, and dark companion, or primary, in a period of about 130 years.

* Suspected by MONTANARI, 1669.

† Questioned by PICKERING, H. C. O. Circ. 7.

‡ PARKHURST's idea that this star is of the *Algol*-type has not yet been confirmed. *X Carinæ* is also suspected to belong to this class, but ROBERTS' announcement still awaits confirmation.

The size of this orbit around the common center of gravity is about equal to that of *Uranus* around the Sun. The plane of the orbit is inclined about twenty degrees to our line of vision. *Algol* transited the plane, passing through the center of gravity perpendicular to this line of vision, in 1804 going outwards, and in 1869 coming inwards. Calling the first point the ascending node, the position-angle, reckoned in the ordinary way, is about sixty-five degrees. The orbit is sensibly circular, or of very moderate eccentricity. The longest diameter of the projected ellipse, measured on the face of the sky, is about 2″.7."

It would take us too far to enter into the proofs of this proposition. It must be sufficient to say that Dr. CHANDLER made out a very strong case, and that subsequent observations and investigations seem to substantiate his argument. CHANDLER further pointed out the fact that analogous irregularities existed in the periods of six, or, perhaps, seven others of the ten stars of this type then known, while two were of too recent discovery to make possible any assertion about the constancy of their periods. "The principle of attributing like effects to like causes allows us to assume, with high probability, that . . . all the stars of this class have similar motions, namely, one around a near companion, the other a common motion of these two bodies around a distant one."

In this connection it is of historical interest to note that Professor WM. FERREL, in 1855, suggested,* as an explanation of the retardation and subsequent acceleration of its period, that *Algol* and its hypothetical close companion revolved about a distant dark companion in a period of perhaps several centuries.

In speaking of *Algol's* close companion, we have called it "*relatively* dark." VOGEL showed that if its light were one eightieth part as intense as that of its primary, a secondary minimum would be produced, caused by the brighter star occulting its faint companion. In at least three of the *Algol*-type stars, viz. *RS Sagittarii*, *Y Cygni*, and *Z Herculis*, this phenomenon has been observed.

According to ROBERTS, the first-named star usually has a magnitude of 6.60; at the chief minimum this becomes 7.59, and at the secondary minimum 6.89. This he accounts for by assuming that one star of the system is nearly twice as bright as

* *Nashville Journal of Medicine and Surgery*, April, 1855. Reprinted in *Astronomy and Astro-Physics*, Vol. XII, p. 429.

the other; that the orbit is eccentric, the line of apsides nearly coinciding with the line of sight; and that the fainter star is almost directly between us and its primary (thus causing the chief minimum) when the stars are at their greatest distance apart.

The secondary minimum in *Y Cygni* differs so little in point of magnitude from the principal one that it is only recognized by the fact that the minima, instead of following each other at uniform intervals, occur at intervals of thirty-two hours and forty hours alternately. Hence, for this star the terms *even* and *odd* minima are used. DUNÉR's explanation of these facts is, that the star consists of two equally large and bright components, revolving about their common center of gravity in an elliptic orbit in a period of nearly three days, the perihelion passages occurring between the even and the odd epochs. The eccentricity of the orbit need only be 0.1 to explain fully all the observations. Observation seems to show that the intervals between even and odd minima are not constant; and this DUNÉR would explain by assuming a third invisible perturbing body, which causes a motion of the line of apsides such as is found in the planets and satellites of the solar system.

Z Herculis differs from *Y Cygni* in that the minima, which occur at intervals of forty-seven and forty-nine hours, respectively, are alternately faint and very bright.

To suit these intervals and magnitudes, DUNÉR finds that we must assume that *Z Herculis* consists of two stars of equal size, one of which is twice as bright as the other. The semimajor axis of the elliptic orbit of the stars is six times their diameter (assuming that one star remains fixed in the focus of the ellipse). The plane of the orbit passes through the Sun, the eccentricity is about 0.25, and the line of apsides is inclined at an angle of four degrees to the line of sight.

While there are still many difficult and interesting problems to solve in connection with the *Algol*-type stars, it is now certain that the solutions will be sought—and probably found—in extensions of the theory of orbital motion; and enough has been said here to indicate the lines along which the investigations are proceeding.

One further characteristic may be mentioned that is common to all these stars, namely, their small mean density. Several investigators have found that the mean density of *Algol* is not

more than one fourth that of water, while other stars of the type are even more tenuous. If these results are correct, the *Algol*-type stars must be completely gaseous.

Turning now to the binary stars which have been revealed by the doubling of the lines in their spectra, we find that, so far, only five have become known to us.

NAME.	DISCOVERER.		PERIOD.
ζ *Ursæ majoris*,	Pickering,	1889	52 days.
β *Aurigæ*,	Miss Maury,	1889	$3^d\ 23^h\ 36.7^m$
μ' *Scorpii*,	Bailey,	1896	1 10 42.5
A. G. C. 10534,	Pickering,	1896	3 2 46
β *Lupi*,	Mrs. Fleming,	1897	Undetermined.

As already stated, ζ *Ursæ majoris* was the first star of this type to reveal its binary character by the periodic doubling of its lines. But it is, nevertheless, the one whose period we are least certain of — with the exception of β *Lupi*, just discovered. As the lines are clearly double about every fifty-two days, the period was at first announced as 104 or 105 days. Later evidence, however, indicates that half this time is the true period, the orbit of the second star about its primary being probably an ellipse of considerable eccentricity, with the major axis nearly perpendicular to the line of sight. In this case the lines would be seen double once in each revolution — at the time of periastron passage,— but would only become broader and blurred at the time of apastron. This theory would seem to fit the observations fairly; but there appear to be irregularities in the period, which may perhaps indicate the presence of a third body. The maximum relative velocity of the two components is found to be about 100 miles per second.

The second star in this list, β *Aurigæ*, is much more rapid and decided in its changes. So rapid, in fact, are the changes in the spectrum, that they are sometimes perceptible, according to PICKERING, in successive photographs, and in the course of an evening are very marked. The distance between the lines when at their greatest separation is so great that measures are easy and accurate. There is a very slight difference in the intensity of the lines, and the fainter line is alternately more and less refrangible than the brighter one. As the measures of the amount of separation in the two positions indicate nearly the same velocity,— about 150 miles per second—it is probable that

the orbit is nearly circular. As the period is four days, it follows, assuming the plane of the orbit to be parallel to the line of sight, that the distance between the stars is about 8,000,000 miles, and the combined mass 2.3 times that of our Sun. If the orbit is inclined to the line of sight, as is probable, these values must be increased by an amount depending on the inclination. PRITCHARD has found the value of the parallax of β *Aurigæ* to be $0''.062$; hence the greatest angular separation of the components is less than $0''.01$. The most powerful existing telescope, therefore, can never make the components visible to us.

μ' *Scorpii* and *A. G. C.* 10534 resemble β *Aurigæ*, in that their periods of revolution are short and the doubling of the lines very marked. In fact, in these respects they surpass the latter star, as the recent measures by Mrs. FLEMING show that the relative velocities of the components are about 286 and 379 miles per second, respectively. In each of these stars one component is noticeably fainter than the other. The relative intensity of the lines in μ' *Scorpii* seems to change, indicating a possible light variation in one of the components; but this needs further investigation.

If we except the short period variable stars, like η *Aquilæ* and δ *Cephei*, which are almost certainly binary systems, but which require additional hypotheses to account for their variability, we have two stars left which call for brief notice, viz. α *Virginis* (*Spica*) and α' *Geminorum*, the principal component of the well-known double star *Castor*. As has been said above, the former was discovered by VOGEL, in 1890, by the shifting of the hydrogen lines in its spectrum alternately toward the red and violet end, with respect to the lines in an artificially produced spectrum of hydrogen. It was thus found that, while the system is approaching the Sun at the rate of nine miles per second, the two components are in orbital motion, with a velocity of about fifty-seven miles per second, completing one revolution in 4.0134 days. In the same way BELOPOLSKY found, in 1896, that the components of α' *Geminorum* complete a revolution about their common center of gravity in 2.91 days.

That the number of known spectroscopic binary stars will be largely increased by future discoveries, is certain, and it is entirely possible that the study of their phenomena, as shown in light variations and changes in spectrum, may yet reveal to us systems more complex than even our own solar system.

The mathematical formulæ, by means of which the elements of a binary star orbit may be computed from measures of the relative velocities of the components in the line of sight, have been fully developed by RAMBAUT,* WILSING,† and LEHMANN-FILHÉS,‡ but the discussion of their methods and results is beyond the province of this article.

LICK OBSERVATORY, University of California,
January 26, 1898.

---

* *Mon. Not. R. A. S.*, March, 1891.
† *A. N.*, 3198.
‡ *A. N.*, 3242.

NOTICES FROM THE LICK OBSERVATORY.*

PREPARED BY MEMBERS OF THE STAFF.

REDISCOVERY OF WINNECKE'S PERIODIC COMET = *a* 1897.

This comet was observed by the writer on the morning of January 2d. At $2^h\ 5^m\ 42^s$ G. M. T. it was in R. A. $15^h\ 19^m\ 2^s.51$ and Decl. $-\ 3^\circ\ 58'\ 34''.3$. It is, therefore, $2^m\ 0^s$ east and $8'.7$ south of the place predicted for it by HILLEBRAND (*Ast. Nach.*, No. 3447).

The comet is very small and faint, about 10″ to 15″ in diameter, and slightly brighter at the center. It is much less favorably situated at the present return than at the last, in 1892, and hence will be faint during this entire apparition and probably not within the range of small telescopes.

This comet was first discovered by PONS in 1819, and a period of five and a half years deduced by ENCKE. It was, however, not seen again until 1858, when it was discovered as a new comet by WINNECKE. It has been observed at the subsequent returns in 1869, 1875, 1886, and 1892. C. D. PERRINE.

THE PROBABLE STATE OF THE SKY ALONG THE PATH OF TOTAL ECLIPSE OF THE SUN, MAY 28, 1900.†

"Having regard to the cost of establishing temporary eclipse stations, and the losses to science in case a clear view of the Sun is not secured during totality, it is proper to determine, as far as practicable, the probable state of the sky along the path, with the view of selecting the best sites for the observations. To do this, a study may be made of the cloud conditions prevailing annually along the shadow track for a period of time, including the date

* Lick Astronomical Department of the University of California.

† Abstract from the Report by Professor FRANK H. BIGELOW, in the *Monthly Weather Review* for September, 1897.

of the eclipse. Certain areas may show greater tendency to cloudiness than others, and this fact will have some weight with observers in choosing their stations.

"The eclipse track for May 28, 1900, passes over the Southern States from New Orleans, La., northeastward to Norfolk, Va., and it will be surveyed by the U. S. Weather Bureau for the benefit of the astronomical expeditions.

" . . . Beginning with May 15, 1897, and continuing until June 15, 1897, so as to include May 28th centrally, observations were made at sixty-six stations, . . . covering quite uniformly the portions of the States of Virginia, North Carolina, South Carolina, Georgia, Alabama, Mississippi, and Louisiana, over which the track is plotted. . . . The *general state of the sky* at 8 A. M., 8:30 A. M., and 9 A. M., was noted. . . . At the same hours *the state of the sky near the Sun* was observed. The observers were generally volunteers, who did this work at the request of the Weather Bureau. . . .

"Judging from the table [of the results of the observations] it would be much safer to locate in central Georgia or Alabama, upon the southern end of the Appalachian Mountains, *where the track crosses the elevated areas*, than nearer the coast line in either direction, northeastward toward the Atlantic coast, or southwestward toward the Gulf coast.

" . . . It is intended to repeat the observations during the years 1898 and 1899, after which we shall be as well informed as possible regarding the selection of the eclipse stations for the year 1900."

ECLIPSES OF *JUPITER'S* SATELLITE IV.

The present cycle of eclipse phenomena for *Jupiter's* fourth satellite is nearly closed, and, of course, the latest observations are among the most favorable for correcting the ephemeris. Immediately after *Jupiter* has made his appearance on this coast, at midnight, January 9th–10th, Satellite IV will suffer eclipse, and the reappearance nearly two hours later should be well observed.

The last eclipse, when the satellite will be only half an hour in the shadow, may possibly be seen from Mt. Hamilton, on the morning of March 1st, when, although the Sun is just above the eastern horizon, *Jupiter* is low down in the west. C. B. H.

SAN FRANCISCO, December 5, 1897.

THE STAR WITH THE LARGEST KNOWN PROPER MOTION.

The star, Cordoba Zone Catalogue, 5^h, No. 243, has been found by Professor J. C. KAPTEYN and Mr. R. T. A. INNES to have an annual proper motion of $+0^s.621$ in Right Ascension and $-5''.70$ in Declination, or of $8''.7$ in the arc of a great circle. The announcement in the *Astronomische Nachrichten*, 3464, states that the discovery was made in comparing the Cape Photographic *Durchmusterung* star places with those of other star catalogues.

The largest known proper motion of any star previous to this discovery was that of the so-called "runaway" star, 1830 Groombridge, which has an apparent drift of $7''.0$ annually.

January 6, 1898. R. G. A.

ASTRONOMICAL TELEGRAM *(Translation).*

Lick Observatory, Jan. 3, 1898.

To Harvard College Observatory,
Cambridge, Mass. (Sent 10:50 A. M.)

Comet WINNECKE was observed by PERRINE, January 2.0873, R. A. $15^h\ 19^m\ 2^s.5$, Decl. $-3°\ 58'\ 34''$. Faint.

OBSERVATIONAL ASTRONOMY: A PRACTICAL BOOK FOR AMATEURS. BY ARTHUR MEE, F. R. A. S.

The library of the Society has become the possessor, through the courtesy of the author, of the second and thoroughly revised edition of what *Knowledge* calls "an excellent, honest little book." A cursory examination indicates that the author is justified in believing "that this second edition may be described as the most detailed work at the price that has ever been offered to the fast-growing circle of amateur astronomers." It is up to date, contains a vast amount of information well arranged, ample references to special treatises and articles in the scientific journals and reports of observatories, and is illustrated with portraits, maps, drawings, and photographs. "Every care has been taken to insure accuracy, and the fanciful results of the recently established school of marvel-mongers are either dismissed altogether, or viewed in these pages with a skeptical eye."

A brief but appreciative memoir of the Rev. Prebendary WEBB, author of the well-known "Celestial Objects for Common Telescopes," is appended.

SOME INTERESTING DOUBLE STARS.

I have recently secured three measures of the star *β 395*, the latest addition to the rank of rapid binary stars. The mean of these measures is, —

1897.92	273°.7	0″.27.

In 1891 BURNHAM'S measures gave an angle of 118° and a distance of 0″.75. According to SEE, the period of this star is about sixteen years.

Measures of O Σ *515*, *φ Andromedæ*, on three nights give a mean result of, —

1887.98	56°.4	0″.23.

This is in good agreement with measures made by Professor HUSSEY about the same time. So far as I know, these are the only measures that have been made since BURNHAM'S rather uncertain measure on one night in 1892, just after the star had passed periastron. The angular motion since 1851, the date of discovery, exceeds 250°.

The star *h 1968*, though not a binary, is interesting because of the relative proper motion of the two close components. The distance, which in 1831 exceeded 20″, is now about 2″.5. A recent discussion by Professor S. GLASENAPP shows that the relative annual motion of B to A is 0″.2753 in the direction 235°.11. The minimum distance, 2″.28, between the stars will be reached in 1904.

The following measures have been made of the companion to *Procyon*:—

1897.838	321°.7	4″.84
.876	324 .8	4 .67
.915	324 .8	4 .59
1897.88	323°.8	4″.70

These measures, like those by Professor SCHAEBERLE, indicate direct orbital motion.

Two measures of the companion to *Sirius* have been secured in addition to those published in No. 59 of these *Publications*. They are:—

1897.838	175°.8	4″.14
.915	172 .8	

Clouds prevented distance measure on the second night. All the above measures were made with the 36-inch telescope.

January 21, 1898. R. G. AITKEN.

ERRATA IN STAR CATALOGUES.

In the course of some work involving an extensive use of southern star catalogues, a few errata and unusual discrepancies have been noted. In general they are of minor importance, but the insertion of the corrections in the catalogues may save some annoyance.

Cordoba Durchmusterung:—

-23° 13035 for G C. read Z C.
-24° 15285 differs $-2'.2$ in δ from Z C. $19^h.695$.
-24° 16622 print G C.
-24° 16626 for G C. read Z C.
-24° 16877 delete Z C.
-24° 16874 print Z C.
-24° 16959 print G C.
-24° 16960 delete G C.
-25° 13024 delete G C.
-25° 13025 print G C.
-25° 15714 for G C. read Z C.
-26° 10862 for G C. read Z C.
-27° 12682 for G C. read Z C.
-28° 6607 delete G C.
-28° 17047 for G C. read Z C.
-28° 17523 Decl. for $32'.0$ read $22'.0$.
-31° 3136 Declination differs $1'.5$ from G C. 7589.
-31° 3^h Right Ascension minute 41 is omitted. It should be printed with No. 1538.
-32° 16677 for G C. read Z C.
-34° 5905, 5906. The magnitudes in C D M. are respectively, 9.6 and 7.9. G C. 12906 gives C D M. 5905 a magnitude of $7\frac{1}{2}$. Are the C D M. magnitudes interchanged?
-34° page 139, for -36° read -34°.
-36° 6426 for 3.5 mag. read 8.5.
-38° 9130 for G C. read Z C.
-39° 14114 Decl. for $29'.1$ read $24'.1$.
-40° 8818 for G C. read Z C.
-40° 9495 delete U A.
-40° 9496 print U A.

Cordoba Zones:—

17^h 2644 Right Ascension is $1^s.1$ greater than G C. 24105.

Cordoba General Catalogue:—

2107, column Prec. An., for $2^s.934$ read $2^s.634$.

ARGELANDER'S Southern Zones (WEISS):—

1607 Declination $1'$ too far south? See G C. 3239.

8708 Declination $1'$ too far south? See G C. 14501.

18236 Right Ascension differs $+1^s$ from G C. 32393.

SCHÖNFELD'S Southern Durchmusterung:—

$-20°$ 5055 is marked A, but is not in WEISS'S *Argelander*.

YARNALL (FRISBY) 327. An. Prec. for $10''.85$ read $19''.85$.

YARNALL (FRISBY) 8888 is called Arg. (Oe) 20215. WEISS gives 50^s less Right Ascension.

R. G. AITKEN.

January 15, 1898.

AWARD OF THE LALANDE GOLD MEDAL TO ASSISTANT ASTRONOMER C. D. PERRINE, OF THE LICK OBSERVATORY.

The members of the Astronomical Society of the Pacific will be pleased to learn that at the meeting of the French Academy of Science, held in Paris, December 30, 1897, the LALANDE Gold Medal was awarded to C. D. PERRINE for distinguished services in astronomy.

Since his connection with the Lick Observatory, Mr. PERRINE has discovered five new comets and rediscovered two periodic comets. In addition to these discoveries, he has not only published long series of observations on these bodies, but has also computed and published various orbits and ephemerides of the new comets from his own observations.

It is quite remarkable that every one of the last five comets observed was successively discovered by this same observer, three being new, and two rediscoveries of the periodic comets of D'ARREST and WINNECKE.

The award of the LALANDE Gold Medal to Assistant Astronomer C. D. PERRINE, is but a just recognition, by one of the world's leading scientific bodies, of a most worthy investigator.

J. M. S.

LICK OBSERVATORY, January 21, 1898.

BELOPOLSKY'S RESEARCHES ON η *AQUILÆ*.

The variable character of η *Aquilæ* was discovered by PIGOTT in 1784, and from the observations since that time the period of its variation in brightness, ranging from 3.5 to 4.7 magnitude, has been determined with great accuracy. According to CHANDLER'S Third Catalogue of Variable Stars, the period is 7.176381 days, or somewhat more than seven days four hours.

In September, 1895, M. BELOPOLSKY reported to the Academy of Sciences of St. Petersburg that his spectrographic observations of this star indicated a variable velocity in the line of sight. During the past year he has again studied the star by means of photographs of its spectrum, taken with improved spectroscopic apparatus in connection with the 30-inch refractor at Pulkowa. His former results have been confirmed. He finds the velocity in the line of sight periodically variable, ranging from $+1.61$ to -18.63 miles per second. Assuming the variations of velocity to be due to orbital motion and with a period of revolution equal to the period of the star as a variable, he has determined elliptic elements, so as to satisfy the observed velocities in the line of sight. It is found that the times of minimum brightness and the times at which the velocity in the line of sight is the same as that of the motion of the system, do not coincide, and for this reason some explanation other than that of eclipses must be sought to explain the variations of brightness.

M. BELOPOLSKY has arrived at a like result in the case of δ *Cephei*, a variable star, whose range in variation of brightness and whose light curve are very much the same as those of η *Aquilæ*.

W. J. HUSSEY.

METEORS VISIBLE IN FULL DAYLIGHT.

The number of shooting stars or meteors that fall to the Earth in the course of twenty-four hours reaches high into thousands, but the great majority of them are small, and do not attract any particular attention. At very rare intervals, however, it happens that they are of sufficient size and brilliancy to be seen in the daytime. The following are among the instances to be found in astronomical records:—

On the afternoon of September 13, 1795, a meteoric stone, weighing fifty-six pounds, fell within thirty feet of a workman in Yorkshire, England. This stone fell with a loud explosion, and penetrated a foot of soil and half a foot of chalk rock.

About nine o'clock in the morning of September 10, 1813, another was seen to fall in southern Ireland. Its appearance was accompanied with the formation of a cloud of smoke in a clear sky. Soon after eleven distinct reports were heard, resembling the discharge of heavy artillery, followed by an uproar like that of the continued discharge of musketry. Bodies moving in a horizontal direction towards the west with great velocity came out of the cloud of smoke. One of these was seen to fall to the Earth, burying itself deep in the ground. It was immediately dug up, and found to be still hot and to have a sulphurous smell. It weighed seventeen pounds. Other fragments fell at the same time, and were picked up in the neighborhood.

In 1879 a meteor was seen to fall in the daytime in Southern Virginia with sounds likened to that of an earthquake.

On the afternoon of January 19, 1898, I observed a bright meteor from the Lick Observatory. It was merely a flash, from five to ten degrees in length. It appeared white against the clear sky and was visible for only a very short time, not more than a few tenths of a second. It was moving very rapidly towards the north in a path slightly inclined towards the Earth, and increasing in brightness along its course until its sudden disappearance. From the observatory it was seen almost directly in the west, but its distance must remain unknown, unless at least one other observation has been secured elsewhere. It was, however, probably far out over the Pacific Ocean.

The time of observation was $1^h\ 8^m\ 40^s$ P. S. T. The azimuth of the point of disappearance, as seen from the Lick Observatory and subsequently determined with surveyor's transit, was south ninety-three degrees west, and its altitude was estimated to be about eight degrees. E. F. CODDINGTON.

January 21, 1898.

REPORT ON THE TEACHING OF ASTRONOMY IN THE UNITED STATES.

The next report of the U. S. Commissioner of Education will contain a chapter by Dr. EDWARD S. HOLDEN on the teaching of astronomy in the primary and secondary schools, and in the colleges and universities of the United States.

Dr. HOLDEN was elected a member of the American Philosophical Society of Philadelphia at its meeting in December, 1897. R. G. A.

Success of the Crocker Lick Observatory Eclipse Expedition.

A cablegram received at Mt. Hamilton from Professor Campbell, who is in charge of the Crocker Lick Observatory Expedition at Jeur, India, states that most satisfactory photographs of the corona were obtained with three different telescopes —one set with a telescope forty feet long, and two other sets with five-foot and three-foot telescopes. He also reports that the great equatorial extension of the corona, which formed such a conspicuous feature of the eclipse of January, 1889, has again been photographed.

He also satisfactorily photographed the changes in the solar spectrum at the Sun's edge with the aid of one of the spectroscopes, and probably obtained successful photographs of the reversing layer with the aid of a second spectroscope.

Professor Campbell originally intended to locate his station in the neighborhood of Karad; but, owing to the ravages of the plague in that section of the country, he was compelled to change his plans, so far as the selection of the station was concerned.

The instrumental equipment of the Lick Observatory Eclipse Expedition was, without doubt, as complete as that of any other party sent out on this occasion, and we believe that the results secured by Professor Campbell will, when fully discussed, add very materially to our knowledge of the Sun's constitution, the nature of the forces there at work, and the character of the Sun's corona. J. M. Schaeberle.

Lick Observatory, University of California,
January 24, 1898.

Death of Dr. Winnecke.

We regret to record the death of Dr. A. F. T. Winnecke, at Bonn, on the 3d of December, 1897. Born at Hanover on the 5th of February, 1835, Winnecke received his training in astronomy at Göttingen, Berlin, and Bonn, coming under the personal influence of Gauss, Encke, and Argelander. Already well known by his work, both in practical and theoretical astronomy, he accepted, in 1858, an appointment in the Russian observatory at Pulkowa. His work here in the next six years placed him in the front rank of astronomers, but his incessant activity overtaxed his strength, and in 1865 he was obliged to return to Bonn

in search of health. The few years following were mainly devoted to regaining his strength, but that his scientific work was not entirely abandoned is sufficiently made evident by the discovery of four new comets during this time. In 1872 he had so far recovered as to be able to accept the appointment of Professor of Astronomy at the newly founded University of Strassburg. Nine years of fruitful work as Director, observer, and instructor followed; but in 1881 failing health compelled him once more to lay aside his work and seek rest. The hope that he might soon resume his duties was never realized.

In discovery, observation, and theoretical astronomy, WINNECKE'S work constitutes a most valuable contribution to the science he loved.

SUCCESS OF THE PIERSON CHABOT OBSERVATORY ECLIPSE EXPEDITION.

On the afternoon of January 24th, the following telegram was received from the Hon. WM. M. PIERSON, of San Francisco:—

"BURCKHALTER cables unqualified success, and weather conditions perfect."

As is well known, this expedition, in charge of CHARLES BURCKHALTER, of the CHABOT Observatory, was sent out at the expense of another member of the Astronomical Society of the Pacific—the Hon. WM. M. PIERSON, of San Francisco, who has taken such lively interest in the affairs of the Society, and aided previous eclipse expeditions in various ways.

According to the above telegram, BURCKHALTER has obtained satisfactory photographs of the corona with his device (described in No. 42 of our *Publications*) for securing detail of both the inner and outer corona on the same negative. J. M. S.

LICK OBSERVATORY, January 25, 1898.

THE GREAT NEBULA IN *ANDROMEDA*.

(See the frontispiece.)

The frontispiece of the present volume is reproduced from a negative which I obtained with the CROCKER photographic telescope of the Lick Observatory on December 21, 1897, with an exposure of five hours.

The Great Nebula in *Andromeda* is the only one that was known before the invention of the telescope. AL-SUFI, in the tenth century, was familiar with the dim, hazy region near the most northern of the three stars composing the girdle of *Andromeda*. The telescope was first turned to this wonderful object by SIMON MARIUS, December 15, 1612. He described it as like a candle shining through horn. It received but little attention until the time of BOULLIAUD, whose attention was directed to it by the passage of the comet of 1664 across that part of the sky. HALLEY described it as being triangular in shape, with the apex of the triangle on the south preceding end, which corresponds to the right of the accompanying reproduction. MESSIER described it more accurately as two luminous pyramids having a common base, the distance from apex to apex being about two thirds of a degree, and the common base being about a quarter of a degree.

The next important advance in our knowledge of this nebula was made by Professor G. P. BOND, September 14, 1847. While examining it with the 15-inch refractor of the Harvard College Observatory, he saw on the north preceding side two dark rifts, nearly parallel to each other. These were observed with many smaller instruments after their discovery by BOND, but they were always drawn as straight lines.

It remained for photography to determine the true form of these rifts. On October 1, 1888, Mr. ISAAC ROBERTS, with his 20-inch reflector, obtained a photograph of this nebula which was a revelation to the astronomical world. It showed for the first time the elliptical form of the nebula, with the rifts extending almost continuously around it, as shown in the accompanying reproduction.

E. F. CODDINGTON.

Minutes of the Meeting of the Board of Directors, held in the Rooms of the Society, January 29, 1898, at 7:30 P. M.

Vice-President Seares presided. A quorum was present. The minutes of the last meeting were approved. The following members were duly elected:—

List of Members Elected January 29, 1898.

Prof. H. D. Curtis	University of the Pacific, College Park, Cal.
Dr. F. P. von Keller	Ardmore, Ind. Terr.
The John Crerar Library	Chicago, Ill.
Mr. Henry Payot	204 Pine St., S. F. Cal.

Mr. Clarence McKenzie Lewis was elected to Life Membership.

It was, on motion,

Resolved, That the name of the Harvard College Observatory, Cambridge, Mass., be added to the list of corresponding institutions.

Adjourned.

Minutes of the Meeting of the Astronomical Society of the Pacific, held in the Rooms of the Technical Society, January 29, 1898.

The meeting was called to order by Mr. Seares. The minutes of the last meeting were approved.

The Secretary read the names of new members duly elected at the Directors' meeting.

A committee to nominate a list of eleven Directors and Committee on Publication, to be voted for at the annual meeting, to be held on March 26th, was appointed as follows: Messrs. E. S. Clark, C. A. Murdock, G. V. Hicks, L. H. Pierson, J. R. Ruckstell.

A committee to audit the accounts of the Treasurer and to report at the annual meeting was appointed as follows: Messrs. Jos. F. Gassmann, A. H. Babcock, and F. H. McConnell.

The following papers were presented:—

1. The Total Solar Eclipse of 1898, by E. W. Maunder.
2. A Series of Star Maps, by C. D. Perrine.
3. Planetary Phenomena for March and April, 1898, by Malcolm McNeill, of Lake Forest.
4. Spectroscopic Binary Stars, by R. G. Aitken.
5. Observations of Variable Stars in 1897, by Torvald Köhl, of Odder, Denmark.

Adjourned.

OFFICERS OF THE SOCIETY.

Mr. William Alvord (Bank of California, S. F.) . . . . *President*
Mr. E. J. Molera (606 Clay Street, S. F.) . . . . . . } *Vice-Presidents*
Mr. Frederick H. Seares (Berkeley, Cal.) . . . . }
Mr. C. M. St. John (U. S. Custom House, S. F.) . . . . . }
Mr. C. D. Perrine (Lick Observator[illegible]) . . . . *Secretary*
Mr. F. R. Ziel (301 California Stree[illegible] S. F.) . . . . *Secretary and Treasurer*

Board of Directors—Messrs. Alv[illegible] Molera, Morse, Miss O'Halloran, Messrs. Perrine, Pierson, Seares, [illegible] Tucker, von Geldern, Ziel.
Finance Committee—Messrs. Wm. M. [illegible]on, E. J. Molera, and C. M. St. John.
Committee on Publication—Messrs. Aitke[illegible], Babcock, Seares.
Library Committee—Messrs. Hussey and Seares and Miss O'Halloran.
Committee on the Comet-Medal—Messrs. Schaeberle and Campbell.

OFFICERS OF THE CHICAGO SECTION.

Executive Committee—Mr. Ruthven W. Pike.

OFFICERS OF THE MEXICAN SECTION.

Executive Committee—Mr. Francisco Rodriguez Rey.

NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only. Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book-keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the *Publications* for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of two dollars per volume to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to the Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the card.

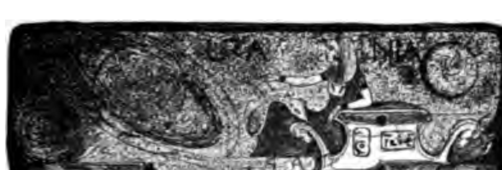
The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States. The responsibility for the views expressed in the papers printed rests with the writers, and is not assumed by the Society itself.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery, stamped with the seal of the Society, at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific" at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.

PUBLICATIONS ISSUED BI-MONTHLY.

(February, April, June, August, October, December.)



A LUNAR LANDSCAPE.

(Photographed at the Lick Observatory, Dec. 31, 1897, $7^h\ 58^m\ 30^s$ to $7^h\ 58^m\ 50^s$, P. S. T.)

PUBLICATIONS

OF THE

Astronomical Society of the Pacific.

VOL. X. SAN FRANCISCO, CALIFORNIA, APRIL 2, 1898. NO. 61

ADDRESS OF THE RETIRING PRESIDENT OF THE SOCIETY, IN AWARDING THE BRUCE MEDAL TO PROFESSOR SIMON NEWCOMB.

BY WILLIAM ALVORD.

At each preceding annual meeting of this Society, it has been the custom for the retiring President to deliver an address, either upon some specialty in the domain of astronomy, or upon some particular features or needs of our organization. The present meeting will of necessity mark a departure from that custom, for it is the first at which the President of this Society is allowed the privilege of making a public award of the Bruce Medal. Following the plan of the older societies similarly endowed, I shall occupy your time this evening with a brief sketch of the life and works of the distinguished American astronomer who, with the sanction (and it might almost be said, at the command) of his fellow scientists of this and many other countries, becomes the recipient of the Bruce Medal of the Astronomical Society of the Pacific "for distinguished services to astronomy."

To those of you who have followed in our *Publications* the history of this recently founded medal and the regulations adopted for its award, it will be perfectly clear that the recipient must have endeared himself, in a scientific sense, to the astronomers of the world. Not only will this also be true of each subsequent bestowal of the medal, but such a condition must especially mark this first presentation, since, according to the desires of Miss BRUCE, the medal is to be "international in character, and may be awarded to citizens of any country and to persons of either sex." It must strike us, then, with peculiar force, that of all the

names of living astronomers that have been so brilliantly connected with the wonderful advances in astronomical research during the past half century, with all the manifold branches of observational work, mathematical investigation, spectroscopic and photographic study in which to seek out a worthy exponent for this distinction, one name stood forward so prominently in the communications from heads of six leading observatories of the world, that the Directors of this Society could but set the seal of their approval upon the verdict of his peers, and award the first Bruce Medal to Professor SIMON NEWCOMB.

The labors of astronomical research are beyond computation in the standards by which, for example, mercantile pursuits are judged. The preliminary study and preparation and the hardships of an apprenticeship in his chosen field would make of a man possessing the requisite mental ability of the great astronomer a most successful business man or practitioner, whose closing days would, in a vast majority of instances, be spent in the luxury of an acquired competence. There are no such pecuniary rewards for scientific devotion. There are, it is true, many noble endowments of scientific research, by means of which the early privations of a few successful students are in a measure lessened and their necessary equipment secured. The scholarships of a great university are an instance of this; would that there were more of them,—such as those established by another distinguished philanthropic woman, by means of which a certain number of advanced students are afforded a course of investigation at the Lick Observatory of our own University. But the idea of an award such as that which it is my glad privilege to make on behalf of the Astronomical Society this evening, is not intended in any sense to be a *reward*. It is, like the gold medal of the Royal Astronomical Society of England, and the Lalande and Arago medals of the French Academy, simply the expression of sincere appreciation for a grand work well accomplished—another jewel in the crown of immortality, which alone rewards the unselfish devotion of a worker in the cause of science.

It was such a design which prompted Miss CATHERINE WOLFE BRUCE, of New York (whose previous benefactions to astronomy are many and judicious), to establish the gold medal of the Astronomical Society of the Pacific. I cannot do better than to here quote one or two sentences from the original announcement made by Dr. EDWARD S. HOLDEN, who had

previously been made the recipient of many aids to the Lick Observatory equipment and publications from the same benefactress, and by whom principally were drawn up the excellent regulations for the bestowal of this medal:—

"Not only will the Bruce Medal tend to the advancement of astronomy, and enable the Astronomical Society of the Pacific to adequately recognize scientific work of the highest class (and these are Miss BRUCE'S only desires), but it will forever connect the name of the founder with the progressive advances of astronomy. Those who are knowing to her very many and wise subventions of astronomical research (a few of which are spoken of in these *Publications*) will welcome this, her latest gift, for personal as well as for scientific reasons. The Society is to be congratulated that Miss BRUCE has selected it as the Trustee to carry out her generous desires. If the trust is executed, as it will be, with intelligence, fidelity, and circumspection, the time will soon come when the Bruce Medal will be one of the most highly-prized recognitions of original and useful service to Astronomical Science."

To members of scientific societies situated in the Eastern States, or even in Europe, the personality of our Medalist is well known. All the world knows of his scientific achievements. I have therefore thought that it would be gratifying to members of the Society if I gave, in this place, some brief account of the life of Professor NEWCOMB, especially because his life exhibits, in a marked way, the qualities which distinguish the great man of science, who is born, not made, and who will conquer his place no matter what the obstacles may be.

Professor NEWCOMB was born in Wallace, Nova Scotia, on March 12, 1835. His family came to New England about 1660, but removed to Nova Scotia in 1761, shortly before the breaking out of the Revolutionary War. None of his ancestors received a college training, but, after the fashion of the times, they were taught in the country schools. His grandfather was a stonecutter by trade, and part owner of a quarry in Nova Scotia. He must have been a man of parts, for among the books in his library was a copy of Euclid's Geometry, not a common possession in the simple community in which he lived. His son, the father of NEWCOMB, became a school-teacher. There was but small opportunity for a boy in the little village in Nova Scotia where NEWCOMB'S family lived. Most of the inhabitants were

very poor. The men and boys sawed lumber and cut wood for a livelihood. The women and girls sheared the sheep and wove the wool into homespun cloth. The garments for both men and women were made at home. Life was hard and books were few.

In his father's school young NEWCOMB began his studies at the age of five. At six he was already fond of arithmetic, and soon gained a local reputation for his facility in working out arithmetical problems. At the age of twelve the boy began the study of algebra, and about the same time he commenced to teach others. The Euclid which belonged to his grandfather was taken down from the bookshelves when the lad was about thirteen years old, and there he obtained his first ideas of geometrical demonstration. As he has himself said: "The book delighted me. It opened up a new world of thought, and I remember that I explained its theorems to my brother, drawing the diagrams with a pencil on the ends of the logs of a pile of wood."[1]

From Nova Scotia young NEWCOMB went, as a country school-teacher to the eastern shore of Maryland, where he taught reading, writing, and arithmetic for a year or more.

Among Professor NEWCOMB'S papers is to be found the following certificate, which was valued then, but which reads quaintly now among the formal diplomas from the learned societies and the universities of the whole world:—

"This is to certify that Mr. SIMON NEWCOMB was well qualified to instruct children in the various branches of an English education, and possesses a good moral character. He exhibited a very considerable knowledge of the higher branches of mathematics.

W. J. SUDLER,
JOHN W. E. SUDLER,
Trustees for Primary School No. 4 of Q. A. Co., for the year ending 1855.

(Dated) Sudlersville, November 23, 1855."

At this time he sent to Professor JOSEPH HENRY, the Director of the Smithsonian Institution, an algebraical problem that was new, asking him if it were suitable for publication. The problem was submitted by Professor HENRY to a mathematician, who reported that, while the demonstration was original, it was not precisely suited for publication. HENRY, with his unfailing kindness, replied to NEWCOMB'S letter and became interested in the young man, who came to Washington at his request. I have heard that he walked from his home to the city. By HENRY'S inter-

vention, NEWCOMB was appointed, in 1857, to be a computer on the American Ephemeris (Nautical Almanac), which was then installed at Cambridge, Massachusetts. The establishment was under the direction of Lieutenant (afterwards Admiral) CHARLES HENRY DAVIS, of the Navy, and DAVIS' relative, BENJAMIN PEIRCE, the Professor of Mathematics and Astronomy in Harvard University, was the consulting astronomer of the Ephemeris. In this new atmosphere NEWCOMB was soon at home. The little brick building on the main street of Cambridge, which was the headquarters of the Ephemeris, contained a number of men of first-rate ability, and many of the officers of the institution had already made their mark. PEIRCE was a pupil and protege of NATHANIEL BOWDITCH, and had read for him the proof-sheets of BOWDITCH'S translation of the *Mécanique Celeste* of LAPLACE as it passed through the press. NEWCOMB'S immediate colleagues were, then or soon afterwards, RUNKLE, FERREL, CHAUNCEY WRIGHT, WINLOCK, and others. KENDALL, SEARS C. WALKER, and Dr. GOULD were coadjutors also. The Harvard College Observatory was in active operation under WILLIAM BOND and his son. The intellectual tone of Cambridge, then a mere village, was extremely high. NEWCOMB found in his new surroundings precisely the atmosphere that was needed for his development. During his stay in Cambridge he attended the Lawrence Scientific School of Harvard University, from which he was graduated in 1858.

Some of his colleagues were men of high and varied culture, and all of them were accomplished in scientific matters. Books there were in plenty. The Observatory was actively engaged in original work. In native talent few, if any, of his companions approached NEWCOMB, but he had something to learn from each one of them. Perhaps his friendship with CHAUNCEY WRIGHT was as close as any. WRIGHT was not only a mathematician; he was also a philosopher, and his friendship was highly prized. GOULD had had the great advantage of a thorough training in Europe by the best astronomers of the period.

NEWCOMB'S reputation steadily grew, and in 1861 he was appointed to be Professor of Mathematics in the United States Navy, and one of the Astronomers at the Government Observatory in Washington. Previous to this (in 1857), he had been appointed on the staff of the American Ephemeris.

In 1861 he received his commission in the Navy, and in the

year 1877 he was appointed to be Superintendent of the American Ephemeris, a position which he held until his retirement in 1896. His official position and his talents brought him the Presidency of the U. S. Transit of *Venus* Commission, and placed him at the head of various boards and scientific expeditions to observe the Transit of *Venus* at the Cape of Good Hope in 1882.

Professor NEWCOMB married a granddaughter of FERDINAND R. HASSLER, who was the first Chief of the United States Coast Survey. Mrs. NEWCOMB has been a veritable helpmate during all the years of his activity, sharing in his trials and in his triumphs, and sparing him all the minor ills of life so far as lay in her power. Of his three surviving children, all girls, one at least has shown decided talent, and has taken a high degree as a physician from a foreign university.

A few words may be said of the individuality of our Medalist as I have learned it from a personal acquaintance, which extends back to 1873, when I was one of the Trustees of the Lick Trust and NEWCOMB its chief adviser; and derived also from the conversation of astronomers who have known him intimately, and who honor and revere his character and attainments. It is proper to here mention that a great deal of the preceding information has been kindly gathered for me by Dr. E. S. HOLDEN, whose acquaintance with our Medalist has been lifelong and intimate.

The basis of Professor NEWCOMB'S character is intellectual and moral honesty pushed to its highest degree. He loves truth and detests shams. He has, as it were, a veritable passion for justice—whether in personal relations or in civic matters. The circumstances of his career have made him ruggedly independent in thought and in speech. The essential quality of his mind is that of a philosopher, rather than that of a mathematician or an astronomer merely. His achievements in the pure sciences have been very extended and extraordinary, but his work in political economy, though not so extensive, has fully proved that if he had devoted himself exclusively to this science, he would have attained the very highest rank. Even as it is, he ranks among the great names. In his treatment of all questions, it is the philosophical habit of his mind which is the most remarkable and the most valuable.

His most original investigation—a new method of investigation in the lunar theory—is marked by philosophic insight as well as by mathematical power and astronomical sagacity.

With all these qualities, there is a notable practicality in his methods of work which has stood him in good stead and enabled him to complete vast labors, which another man scarcely less gifted might not have been able to bring to a termination. The tendency of the practical astronomer, who is this and nothing more, is to refine on his observations until they have been brought to the last possible degree of attainable precision and even carried beyond it. In all of NEWCOMB'S work in practical astronomy, he has kept clearly in mind the object for which his observations were made; and when his observations were sufficiently accurate, and when there was an adequate number of them, he has terminated the work and calculated the desired result with the least possible delay. In this way he has saved himself and the world much time. His results have been quickly forthcoming. The merit is great. The danger of such a procedure is, that results may be too quickly reached and accepted on authority.

In theoretical researches the same practical tendency is manifest, and corresponding results have been attained. It is due to this faculty that the enormous task of revising the elements of the orbits of the major planets and of tabulating them in convenient forms has been carried through to completion in a comparatively short time. This gigantic task would have been above even his powers, had it not been for this practicality to which I have referred.

In pure mathematics his work has chiefly been directed to investigations that were suggested by the needs of astronomy as experienced in his previous work. His mathematical thinking has usually been along lines suggested by astronomical necessities.

On a few occasions he has made successful excursions into the geometry of Hyper-Space. These "fairy tales of geometry" are very attractive to his mind, so that he chose for the subject of his Presidential Address to the American Mathematical Society (1897), "The Philosophy of Geometry of Four-Dimensions."

His many mathematical text-books are characterized by a practical tendency which gives them great value, and at the same time the philosophical bent of his mind has forced him to regard the subjects treated from a high and generalized point of view.

The list of Professor NEWCOMB'S honors is a very long one. He is a member of nearly every Academy of Science in Europe, and has received honorary degrees from many universities in this

country and abroad. In 1872 he was elected one of the fifty Foreign Associates of the Royal Astronomical Society of London, and in 1874 he received the gold medal of that Society.

In 1877 he was elected a foreign member of the Royal Society of London, and the Copley Medal was awarded to him in 1890.

In 1877 he was President of the American Association for the Advancement of Science, and in the same year his portrait was ordered to be painted for the gallery of portraits of great astronomers in the Imperial Observatory of Russia.

In 1878 he received the Huyghens Medal from Holland, an award which is made only once in each twenty years, and then only for the most important work of the period.

He has been corresponding member of the Academy of Sciences of Paris since 1874, and one of its eight Foreign Associates since 1895, and an officer of the Legion of Honor of France since 1896.

In 1897 the Imperial Academy of Sciences elected him to membership, and in the same year he received the Schubert Gold Medal of the Academy—a rare honor.

In acknowledgment of his services to the Imperial Observatory of Russia in the making of its great telescope, the Czar presented him with a magnificent onyx vase, and the Japanese Government has also presented him with a pair of bronze vases. He was Vice-President of the National Academy of Sciences during the years 1883 to 1889, and President of the American Mathematical Society in 1897. He was the adviser of the Lick Trustees from the beginning, and it was upon his plans that the object-glass of the great telescope was contracted for.

For ten years he was head of the Department of Mathematics and Astronomy in the Johns Hopkins University, and editor of the *American Mathematical Journal.* This long list of honors is more than sufficient to exhibit the estimation in which Professor NEWCOMB's magnificent labors are held. His highest praise may be succinctly expressed by saying, what is the undoubted fact, that he has done more than any other American since FRANKLIN to make American Science respected and honored throughout the entire world.

To these high honors, which have been fully deserved, the Astronomical Society of the Pacific adds its first award of its Bruce Gold Medal "for distinguished services to astronomy."

During the Franco-Prussian War NEWCOMB was at the

Observatory of Paris engaged in examining its records for data necessary in his researches on the motions of the principal planets. He entered the city just as the siege terminated, and prosecuted his work in the midst of the horrors of the Commune, passing the barricades daily in going to and from his study at the observatory.

Professor NEWCOMB is not only an astronomer and mathematician. He has made a name in political economy as well. In 1865 his book, "A Critical Examination of Our Financial Policy," was well received. His "A B C of Finance" (1877) had a very large sale and was extremely useful coming at that time. His work, "Political Economy" (1886) is a text-book in many colleges. A favorite saying of NEWCOMB's has been, "Astronomy is my profession, and political economy my recreation."

I will not attempt to here enumerate the separate works of Professor NEWCOMB. His writings upon astronomical subjects not only fill countless pages of the leading journals, both of this country and of Europe, but occupy whole volumes upon the shelves of every standard library. All who have read his "Popular Astronomy" have been impressed with the charm of the narration no less than with the simple and direct explanation of the most difficult points. The concluding chapters on the "Stellar Universe," the "Plurality of Worlds," and the "Nebular Hypothesis" are the reflections of a true philosopher.

Outside of his mathematical works and treatises on planetary and lunar theories, many of which have been published by the American Government as appendices to "Washington Astronomical and Meteorological Observations" (yearly), and as "Professional Papers of the Nautical Almanac" (periodically), Professor NEWCOMB has, in addresses delivered before learned bodies, and in contributions to the different magazines, made frequent incursions upon the literature of widely different subjects. In addition to the works upon political economy already mentioned, there may be specified his essays upon: "Abstract Science in America" (*North American Review*, January, 1876); "The Course of Nature" (*Popular Science Monthly*, October, 1878); "Formative Influence" (*Forum*, April, 1891); "Why We Need a National University" (*North American Review*, February, 1895); "Science During the Victorian Era" (*The Independent*, June 17, 1897); besides the addresses at the dedications of many important observatories, the latest and perhaps most

prominent of which was the oration upon the "Aspects of American Astronomy," delivered at the opening of the Yerkes Observatory in October last.

He has developed the theories, and prepared tables of the moon and all the planets, besides investigating all the principal "Constants" of astronomy, and his results are accepted as standard places of the fundamental stars, upon the accuracy of which the reliability of the deduced planetary and lunar movements must necessarily depend. And he has even found time for an extended investigation of the theory of the asteroids.

In the opinion of Professor HOLDEN, who for many years prepared the Smithsonian Reviews of "Astronomical Progress," and is a recognized authority upon Astronomical Bibliography, the *best* thing that NEWCOMB has done is his "New Method in the Lunar Theory"; and the *biggest* thing his "Series of Planetary Tables."

Although Professor NEWCOMB has retired from the management of the "American Ephemeris," it is certain that his contributions to astronomy are by no means ended, and that as long as he is spared to mankind his pen will be industrious for the ennoblement of Science, and the demonstration of Truth. A full and complete list of his writings may well be left to more competent hands at that day (which we all hope may be far remote) when his grand work shall have been finished, and when full justice may be done to the vast output of that mighty intellect.

When future Boards of Directors of this Society shall award subsequent Bruce Medals, the recipients thereof may well look back upon this date and think that the first one was tendered to, and accepted by, the foremost American astronomer. The first name has been entered upon a glorious roll of honor that will reflect credit alike upon this Society, the wise and beneficent lady who founded the medal, and upon the achievements of those who explore the boundless depths of the Universe.

Mr. Secretary, in the absence of our Medalist, whose presence here, had it been possible, would have been an additional source of satisfaction to this Society, I beg to hand you the award for transmission to Professor NEWCOMB.

WILLIAM ALVORD.

SAN FRANCISCO, April 2, 1898.

PLANETARY PHENOMENA FOR MAY AND JUNE, 1898.

By Professor Malcolm McNeill.

May.

Mercury passes inferior conjunction and becomes a morning star on the morning of May 1st. It moves rapidly away from the Sun, but toward a more southern position, so that, although its greatest elongation of twenty-four degrees, which it reaches on May 28th, is above the average, its southern position makes it difficult to see. It may possibly be seen for a few days at the close of the month near the eastern horizon in the morning twilight.

Venus is an evening star, gradually increasing its distance from the Sun, setting about two hours later at the close of the month. It moves nearly forty degrees eastward during the month, through the constellation *Taurus* into *Gemini* (See Map III), passing μ *Geminorum* just before the close of the month.

Mars is a morning star, rising somewhat earlier than during April. It is growing a little brighter, but has not increased very much as yet. It moves twenty-one degrees east and nine degrees north during the month, in the constellation *Pisces*. There are no bright stars in the constellation, but it is on Map I, between *Pegasus* and *Cetus*.

Jupiter is in good position for observation all through the evening until after midnight, and may be found on Map III, a little east of η *Virginis*. It moves about one degree westward until May 27th, and then moves eastward.

Saturn is getting into better position for evening observation, rising a little before sunset at the close of the month. It may be found on Map IV, about six degrees north and a little east of α *Scorpii*. It moves about two degrees westward during the month. It is in opposition with the Sun on the morning of May 30th. The ratio of apparent axes of the rings is about 23/100.

Uranus is near *Saturn*, and may be found on the same Map IV, about eight degrees west of that planet. It moves a little more than one degree westward, and early in the month passes β *Scorpii*, less than one degree to the south of the star.

Neptune is an evening star, in the constellation *Taurus*, Map III. *Venus* passes two degrees to the north of it on May 19th.

JUNE.

The Sun reaches its greatest northern declination, and summer begins on June 21st, 2 A.M., Pacific time.

Mercury is a morning star until June 30th, when it passes superior conjunction. During the first ten days of the month it rises about an hour before sunrise, and may possibly be seen under favorable atmospheric conditions, but it is not in very good position for observation.

Venus increases its distance from the Sun about seven degrees during the month, but as its motion in declination is southward, its setting time remains about two hours after sunset throughout the month. It moves thirty-eight degrees east and six degrees south, through the constellations *Gemini* and *Cancer*, into the western part of *Leo*, passing about five degrees south of β *Geminorum* a little before the middle of the month (Map III).

Mars rises about an hour earlier than during the corresponding part of April. It moves twenty-one degrees east and seven degrees north, through the constellations *Pisces* and *Aries*, and may be found on Map I. It passes several degrees south of the stars in *Aries*, which are marked on the map.

Jupiter is still in good position for evening observation, as it does not set before midnight until nearly the close of the month. It may be found on Maps II or III, in the constellation *Virgo*, not far from η *Virginis*, and at the end of the month it is only about one degree west and north of the star. It has moved a little eastward and southward during the month.

Saturn passed opposition with the Sun at the end of May, and is above the horizon nearly the entire night. It moves about two degrees westward, in the constellation *Scorpio* (see Map IV), and is about seven degrees north of α *Scorpii*.

Uranus is near *Saturn*, about eight degrees west, on the same Map IV. It moves about one degree westward, and at the close of the month it is about two degrees westward and $0^\circ.5$ south of the star β *Scorpii*.

Neptune is close to the Sun throughout the month, and is in conjunction with it on June 12th.

Occultation. The Moon approaches very close to the first-magnitude star α *Scorpii* on the evening of June 3d, and there may be an occultation of the star for places in the northern part of the United States.

Explanation of the Tables.

The phases of the Moon are given in Pacific Standard time. In the tables for Sun and planets, the second and third columns give the Right Ascension and Declination for Greenwich noon. The fifth column gives the local mean time for transit over the Greenwich meridian. To find the local mean time of transit for any other meridian, the time given in the table must be corrected by adding or subtracting the change per day, multiplied by the fraction whose numerator is the longitude from Greenwich in hours, and whose denominator is 24. This correction is seldom much more than 1^m. To find the standard time for the phenomenon, correct the local mean time by *adding* the difference between standard and local time if the place is west of the standard meridian, and *subtracting* if east. The same rules apply to the fourth and sixth columns, which give the local mean times of rising and setting for the meridian of Greenwich. They are roughly computed for Lat. 40°, with the noon Declination and time of meridian transit, and are intended as only a rough guide. They may be in error by a minute or two for the given latitude, and for latitudes differing much from 40° they may be several minutes out.

Phases of the Moon, P. S. T.

			H. M.
Full Moon,	May	5,	10 34 P. M.
Last Quarter,	May	12,	1 36 P. M.
New Moon,	May	20,	4 58 A. M.
First Quarter,	May	28,	9 14 A. M.

The Sun.

1898.	R. A. H. M.	Declination. ° ′	Rises. H. M.	Transits. H. M.	Sets. H. M.
May 1.	2 35	+15 10	5 4 A.M.	11 57 A.M.	6 50 P.M.
11.	3 13	+17 58	4 53	11 56	6 59
21.	3 53	+20 15	4 44	11 56	7 8
31.	4 33	+21 58	4 38	11 57	7 16

Mercury.

May 1.	2 34	+15 41	5 1 A.M.	11 56 A.M.	6 51 P.M.
11.	2 18	+11 31	4 20	11 0	5 40
21.	2 25	+10 42	3 52	10 29	5 6
31.	2 57	+13 20	3 35	10 21	5 7

Venus.

May 1.	3 50	+20 24	5 59 A.M.	1 12 P.M.	8 25 P.M.
11.	4 42	+22 57	6 2	1 25	8 48
21.	5 35	+24 25	6 8	1 38	9 8
31.	6 28	+24 44	6 21	1 52	9 23

Mars.

1898.	R. A. H. M.	Declination. ° ′	Rises. H. M.	Transits. H. M.	Sets. H. M.
May 1.	0 9	− 0 18	3 33 A.M.	9 32 A.M.	3 31 P.M.
11.	0 38	+ 2 45	3 12	9 21	3 30
21.	1 6	+ 5 44	2 50	9 9	3 28
31.	1 34	+ 8 36	2 29	8 58	3 27

Jupiter.

May 1.	12 7	+ 0 52	3 25 P.M.	9 28 P.M.	3 31 A.M.
11.	12 5	+ 1 5	2 43	8 46	2 49
21.	12 4	+ 1 11	2 2	8 6	2 10
31.	12 4	+ 1 10	1 22	7 26	1 30

Saturn.

May 1.	16 39	− 20 12	9 15 P.M.	2 3 A.M.	6 51 A.M.
11.	16 36	− 20 6	8 32	1 21	6 10
21.	16 33	− 20 0	7 50	12 39	5 28
31.	16 30	− 19 54	7 3	11 52 P.M.	4 41

Uranus.

May 1.	16 1	− 20 29	8 38 P.M.	1 25 A.M.	6 12 A.M.
11.	15 59	− 20 24	7 57	12 44	5 31
21.	15 58	− 20 20	7 15	12 3	4 51
31.	15 56	− 20 14	6 30	11 18 P.M.	4 6

Neptune.

May 1.	5 20	+ 21 50	7 24 A.M.	2 42 P.M.	10 0 P.M.
11.	5 21	+ 21 51	6 46	2 4	9 22
21.	5 23	+ 21 53	6 8	1 26	8 44
31.	5 24	+ 21 55	5 30	12 48	8 6

Eclipses of *Jupiter's* Satellites, P. S. T.

(Off right-hand limb, as seen in an inverting telescope.)

		H. M.			H. M.
I, R,	May 1.	9 4 P. M.	I, R,	May 17.	7 21 P. M.
II, R,	3.	9 1 P. M.	II, R,	18.	2 14 A. M.
I, R,	8.	10 58 P. M.	III, D,	23.	9 43 P. M.
I, R,	10.	5 27 P. M.	III, R,	24.	12 9 A. M.
II, R,	10.	11 37 P. M.	I, R,	24.	9 16 P. M.
I, R,	16.	12 52 A. M.	II, R,	28.	6 9 P. M.
III, D,	16.	5 44 P. M.	III, D,	31.	1 42 A. M.
III, R,	16.	8 12 P. M.	I, R,	31.	11 10 P. M.

Phases of the Moon, P. S. T.

		H. M.
Full Moon,	June 4,	6 11 A. M.
Last Quarter,	June 10,	10 4 P. M.
New Moon,	June 18,	8 19 P. M.
First Quarter,	June 26,	8 54 P. M.

The Sun.

·98.	R. A. H. M.	Declination. ° ′	Rises. H. M.	Transits. H. M.	Sets. H. M.
e 1.	4 38	+22 6	4 39 A.M.	11 58 A.M.	7 17 P.M.
11.	5 19	+23 7	4 35	11 59	7 23
21.	6 0	+23 27	4 37	12 2 P.M.	7 27
y 1.	6 42	+23 6	4 40	12 4	7 28

Mercury.

e 1.	3 1	+13 44	3 34 A.M.	10 21 A.M.	5 8 P.M.
11.	3 57	+18 26	3 32	10 37	5 42
21.	5 15	+22 56	3 53	11 16	6 39
y 1.	6 49	+24 24	4 40	12 10 P.M.	7 40

Venus.

e 1.	6 33	+24 42	6 22 A.M.	1 53 P.M.	9 24 P.M.
11.	7 26	+23 42	6 41	2 7	9 33
21.	8 17	+21 35	7 1	2 18	9 35
y 1.	9 6	+18 30	7 23	2 28	9 33

Mars.

e 1.	1 37	+ 8 53	2 26 A.M.	8 57 A.M.	3 28 P.M.
11.	2 5	+11 34	2 5	8 45	3 25
21.	2 33	+14 2	1 46	8 34	3 22
y 1.	3 2	+16 16	1 26	8 23	3 20

Jupiter.

e 1.	12 4	+ 1 9	1 18 P.M.	7 22 P.M.	1 26 A.M.
11.	12 5	+ 1 0	12 41	6 44	12 47
21.	12 7	+ 0 44	12 5	6 7	12 9
y 1.	12 10	+ 0 21	11 30 A.M.	5 31	11 32

Saturn.

e 1.	16 30	−19 54	6 59 P.M.	11 48 P.M.	4 37 A.M.
11.	16 27	−19 48	6 15	11 5	3 55
21.	16 24	−19 42	5 33	10 23	3 13
y 1.	16 21	−19 38	4 50	9 41	2 32

Uranus.

e 1.	15 56	−20 14	6 26 P.M.	11 14 P.M.	4 2 A.M.
11.	15 55	−20 9	5 44	10 33	3 22
21.	15 53	−20 5	5 3	9 52	2 41
y 1.	15 52	−20 1	4 23	9 12	2 1

Neptune.

e 1.	5 25	+21 55	5 25 A.M.	12 44 P.M.	8 3 P.M.
11.	5 26	+21 56	4 47	12 6	7 25
21.	5 28	+21 58	4 10	11 29 A.M.	6 48
y 1.	5 29	+21 59	3 32	10 51	6 10

ECLIPSES OF *JUPITER'S* SATELLITES, P. S. T.

(Off right-hand limb, as seen in an inverting telescope.)

		H. M.				H. M.
I, R,	June 2.	6 39 P. M.		II, D,	June 18.	11 33 P. M.
II, R,	4.	8 45 P. M.		I, R,	23.	11 23 P. M.
I, R,	8.	1 5 A. M.		I, R,	25.	5 52 P. M.
I, R,	9.	7 34 P. M.		III, D,	28.	5 41 P. M.
II, D,	11.	8 56 P. M.		III, R,	28.	8 1 P. M.
II, R,	11.	11 22 P. M.		II, R,	29.	5 51 P. M.
I, R,	16.	9 29 P. M.				

LIST OF EARTHQUAKES IN CALIFORNIA FOR THE YEAR 1897.

COMPILED BY C. D. PERRINE.

The following list is a continuation of similar reports printed in these *Publications:* Vol. II, p. 74; Vol. III, p. 247; Vol. V, p. 127; Vol. VI, p. 41; Vol. VII, p. 99; Vol. VIII, p. 222, and Vol. IX, p. 37. A more complete account will be published by the Unites States Geological Survey as a bulletin. The dates are civil dates. The times are Pacific Standard (120th meridian).

Roman numerals enclosed in parentheses indicate the intensity on the ROSSI-FOREL scale.

Some doubtful cases have been included, and are indicated either by a note or by an interrogation point enclosed in parentheses.

In 1897 there were twenty-five shocks of earthquake recorded in California as against sixteen for the year 1896.

The shock of June 20th was accurately timed at Mt. Hamilton and Oakland, and as we know approximately the center from which the disturbance radiated, we can obtain the velocity over this part of its path. At Mt. Hamilton the beginning was noted at $12^h\ 12^m\ 56^s$ P.M., P. S. T., by several observers, and Mr. BABCOCK obtained $12^h\ 13^m\ 9^s$ as the time of the same phase in Oakland, an interval of thirteen seconds. Assuming the epicentrum to have been between San Juan and Salinas, we find Mt. Hamilton to be forty miles from this point, while Oakland is eighty miles. As both points lie nearly in the same direction from the origin of the disturbance, differing only twenty degrees, we may assume that the disturbance moved with the same velocity

towards both stations, from which we find the velocity between Mt. Hamilton and Oakland to be $3\frac{1}{11}$ miles per second.

This is an unusually high velocity, and in this connection it will be interesting to note the intervals in the cases of other shocks, which have been timed with sufficient accuracy.

1889.	July	31.	L. O.-East Oakland,	$-\ 11^s$
			L. O.-San Francisco,	$+\ 7^s$
1890.	April	24.	San Francisco-San José (U. P.),	$-\ 40^s$
	May	11.	San Francisco-East Oakland,	$\pm\ 0^s$
1891.	January	2.	L. O.-San Francisco,	$-\ 22^s$
			L. O.-San José,	$-\ 12^s$
	June	28.	L. O.-San Francisco,	$-\ 10^s$
	October	11.	San Francisco-Oakland,	$-\ 17^s$
1892.	April	19.	L. O.-Carson, Nev.,	$-\ 70^s\pm$
	April	21.	San Francisco-Reno, Nev.,	$-\ 107^s$
1896.	July	26.	L. O.-San Francisco,	$+\ 15^s$

The April, 1892, shocks had their origin in the great central valley of California, and we may safely take a point near Vacaville as the epicentrum of both disturbances. Assuming that the velocity was the *same at equal distances from this point*, we find, for the shock of April 19th, an average velocity of 0.8 miles per second for a distance of fifty-six miles from Carson, Nevada, measured towards the center of disturbance. The interval of time of seventy seconds is somewhat uncertain, perhaps ten seconds or fifteen seconds. For the shock of April 21st, we find an average velocity of 0.8 miles for ninety miles from Reno.

The epicentra for the other cases are entirely too uncertain to base any velocities upon.

List of Earthquake Shocks, 1897.

January 1. Berkeley, 1:10 P.M.

January 11. Oaxaca (Mexico), 4:25 P.M.

January 16. Mt. Hamilton, $3^h\ 58^m\ 38^s$ A.M. (I).

January 17. San Francisco, $1^h\ 9^m$ P.M.; Alameda, $1^h\ 11^m$ P.M.; Oakland, $1^h\ 11^m\ 11^s$ P.M. (A. H. B.), $1^h\ 10^m\ 55^s \pm 2^s$ (G. R. L.); Mills College, $1^h\ 11^m$ P.M.

January 26. Newport, Alsa Bay (Oregon), $2^h\ 45^m$ P.M.

February 2. Tomales.

February 5. Orizaba Volcano (Mexico).

February 13. Colima, Tepic (Mexico).

February 18. Mt. Hamilton, $8^h\ 3^m\ 52^s \pm 5^s$ P.M. (I) C. D. P.; $8^h\ 4^m\ 30^s \pm$ P.M. (II) E. S. H.

The above are two separate shocks. C. D. P.

February —. Cacaluta (Mexico).

February —. Great Salt Lake (Utah). (?)

March 6. Acapulco, Vera Cruz, Oaxaca, Orizaba, Cordoba (Mexico), $7^h\ 30^m$ P.M.

March 13. Mt. Baker (Wash.) (?)

March 15. Ukiah, 11^h P.M.

March 15. Highland Springs, Pieta, Lakeport, $10^h\ 51^m$ P.M. Reported by Mr. WM. B. COLLIER.

April 10. Mexico, south of Oaxaca.

May 14. Moro Bay. (?)

May 14. Reno (Nevada), 6 P.M.

May 15. San Diego, 4 A.M.; Carson (Nevada), 11:04 A.M.

May 22. San Diego, 6:58 A.M.

June 20. A heavy shock of earthquake was felt generally throughout the central portion of California shortly after noon. The center of the disturbance seemed to be in the Salinas Valley. Considerable damage was done to buildings in towns in this and neighboring valleys. Mt. Hamilton, $12^h\ 12^m\ 56^s$ (beginning). Duration, 20^s–30^s (V); College Park; Mills College, reported by Professor KEEP; Oakland, $12^h\ 13^m\ 9^s$ to $13^m\ 34^s$ P.M., reported by Mr. A. H. BABCOCK; Cantua Creek (Fresno Co.), reported by Mr. S. C. LILLIS; San José; Gilroy; Hollister; Salinas; Los Gatos; Santa Cruz; Templeton; Monterey; Pacific Grove; Stockton; Modesto; Newman; Merced; Visalia; Milton; Santa Rosa; Haywards; Decoto; Sacramento; Watsonville; Hanford; San Francisco, 6:37 A.M., 12:15 P.M., 12:48 P.M.; Gonzales; Fresno; Redwood City; San Rafael.

June 20. Tehuantepec (Mexico).

June 21. Gilroy, 5:15 A.M.; Salinas.

June 24. Santa Barbara, 6:10 A.M.

June 26. Tehuantepec (Mexico).

June (26 ?). Douglas Island (Alaska). Volcano.

June (27 ?). "Saw Mill" Peak, Butte Co. (?)

July 19. Santa Barbara, 11:45 P.M.

July 26. Mt. Hamilton, $5^h\ 40^m\ 50^s$ P.M. (III) E. S. H.; San Francisco, $5^h\ 40^m\ 35^s$ P.M., reported by Professor GEORGE DAVIDSON; Berkeley; Oakland.

September 27. Olympia (Wash.), 1:30 A.M.
October 2. College Park, $8^h\ 41^m\ 57^s.3$ A.M., reported by Professor H. D. CURTIS; San Francisco.
October 5. Stockton, 7:44 P.M.
October 17. Mt. Hamilton, $3^h\ 30^m\ 26^s–31^s$ P.M. (III); San José.
November 21. Randsburg, 11:30 A.M.; 12:30 P.M.
December 6. Forest Grove (Oregon), 8:30 P.M.
December 10. Mt. Hamilton (in night).
December 15. Waterville, Lakeside (Wash.).
December 16, 17, 20. Lakeside (Wash.), 6 A.M.
December 23. Mills College, 5:15 A.M. Reported by Professor KEEP.
December 26. Centerville, 7:06 A.M.

LATITUDE WORK WITH THE FAUTH TRANSIT INSTRUMENT OF THE LICK OBSERVATORY.

By HEBER D. CURTIS.

At the suggestion of Dr. HOLDEN, I last summer entered upon a trial of the four-inch FAUTH transit of the Lick Observatory to determine its value as a zenith telescope for finding the latitude.

The latitude level found in place upon the transit was rejected because of irregular curvature. After tests on all the level-tubes in the possession of the observatory, the tube "REPSOLD, No. 1491" was selected as being the most regular. Nearly six hundred readings were made on the REPSOLD level-trier belonging to the observatory, to determine the value of the division of this level, at temperatures ranging from 45° to 83° F. It was found to be a tube of very regular curvature.

In reversing the transit with the aid of the carriage, it is necessary to place the telescope in a horizontal position, thus bringing the level-tube to a position greatly inclined to the horizon, invariably shortening or lengthening the bubble, and making it necessary to bring back the bubble to a more moderate length. It therefore became necessary to determine whether any factor of change in the value of a level division could be found to depend upon change in bubble length. Accordingly the length of the

bubble was varied in the different series of trials from 14.47 mm. to 45.90 mm. The resulting equations of condition gave, as a value of this factor, $0''.0004$ (L—28.3 mm.)—practically zero.

The temperature factor was much more interesting. Above 52° the value of one division may be represented by the formula,—

$$d = 1''.358 + (60^\circ - T^\circ)\ 0''.002.$$

Below 52° (no opportunity was found below 45°) the change is much more rapid, all values being best satisfied by the formula,—

$$d = 1''.374 + (52^\circ - T^\circ)\ 0''.021.$$

The probable errors of all the mean values of the different series used in the formation of these equations are small, in only one case exceeding $0''.005$. The tube was twice removed from its enclosing tube, and tried without it, to determine whether any strain in the mounting caused the curious increase below 52°. Some internal strain in the glass seems the best explanation.

No evidence was found, from a considerable number of transits of stars, to warrant altering the assumed value of one revolution of the micrometer screw: $2^s.931 = 43''.96$. Tests were, however, made on the micrometer screw for periodic error. The micrometer box was placed on the measuring engine, and set at quarter-revolutions, from − 20 to + 20 revolutions. At each setting four bisections were made with the microscope of the measuring engine, and the averages of these sets of readings were so grouped as to bring all readings of the same quarter-revolution of the micrometer head together. The screw of the micrometer, as well as the screw of the measuring engine, worked against the springs. The following values were found (in terms of one revolution of the measuring engine micrometer screw):—

0.00 to 0.25	$1^r.2189$
0.25 to 0.50	1 .2195
0.50 to 0.75	1 .2231
0.75 to 1.00	1. 2238
Mean,	1.2213 ± 0.0010

This periodic irregularity is entirely insensible; the maximum variation between readings in the first and fourth quadrants, due to this cause, would be but $0''.021$, and, in the long run, the resulting errors would tend to balance each other. There was no evidence of variation in the screw at different portions of its length.

THE ROYAL OBSERVATORY, EDINBURGH, FROM THE SOUTHWEST.

The latitude observations themselves show that the instrument as it stands is not well adapted for use as a zenith telescope. As it is now arranged, much time is lost in reversal, and the greatest care must be taken, else the latitude level, which is a later addition, will strike the clamp. The fact that the level-tube must be greatly inclined to the horizon in reversing, is most objectionable, as errors are almost certain to be introduced. With some arrangement by which the reversal could be easily and rapidly accomplished without altering the inclination of the telescope, this instrument would doubtless give good results in latitude work.

In all, after rejecting numerous obviously erroneous observations, 116 were used.

The resulting value of the latitude of the transit instrument was found to be $37° 20' 24''.4$, with the large probable error of $\pm 0''.31$.

University of the Pacific,
College Park, Cal., February, 1898.

THE ROYAL OBSERVATORY, EDINBURGH, SCOTLAND.*

By R. G. Aitken.

About the middle of 1888 the Earl of Crawford and Balcarres offered to the Government, for use in a national Scottish observatory, the splendid and valuable equipment of his own observatory at Dun Echt.

The Government accepted the gift; but the space available in the Royal Observatory on the Calton Hill being entirely inadequate for the housing of the instruments, a new building became necessary; and eventually the present site of three and one half acres on the eastern slope of Blackford Hill was chosen. The plans of the new observatory were prepared by Mr. W. W. Robertson, of Her Majesty's Board of Works, and the build-

*This description is based upon an article by Mr. Thomas Heath, B. A., Assistant Astronomer, Royal Observatory, Edinburgh, read before a meeting of the Royal Scottish Society of Arts, November 23, 1896; a letter from Mr. Heath to Professor Holden; and an article in the *Scotsman*, April 4, 1892. Many of the sentences are directly quoted from one or another of these papers.

ings erected by Messrs. W. and J. KIRKWOOD, of Edinburgh, at a cost, including fittings, of about £34,000.

The buildings consist of an observatory proper and transit house, placed along the north front of the site, and two detached residences for the Astronomer Royal and his assistants. The observatory proper consists of a T-shaped building, with a frontage toward the north of 180 feet. The flat-roofed central buildings are flanked by octagonal towers of unequal size, crowned with cylindrical domes of copper—the larger, 75 feet high and 40 feet in diameter, placed at the east end; and the smaller, 44 feet high and 27 feet in diameter, placed at the west end. These towers contain the two large equatorial telescopes—the 15-inch refractor from the Dun Echt Observatory being placed in the eastern or larger tower, which from its height allows the telescope to sweep the entire horizon; and the 24-inch reflector from the Calton Hill Observatory in the western tower, where it will command the horizon, except for the part cut off by the larger tower. The piers are built of brick, and are hollow, affording room in the larger one for a vault, in which the two standard sidereal clocks are placed, to be protected from any but the most gradual changes of temperature. In addition to this precaution, one of the clocks, known as the Brisbane clock, has also been enclosed in an air-tight case, in order to avoid errors arising from changes of atmospheric pressure. The inner air is partly exhausted until the barometer within the case reads twenty-five inches, at which reading the barometer is to be kept. By the aid of a stuffing box containing quicksilver, the clock is wound without opening the case.

The 15-inch equatorial is completely equipped with the most modern apparatus for every kind of astronomical work—a series of eyepieces of different powers, a micrometer of the most perfect construction, a ZÖLLNER astrophotometer, and several spectroscopes, one of which is among the most powerful in existence. It was with the last-named instrument, designed by himself, that Professor COPELAND was enabled to make the very notable discovery of the presence of helium in the great nebula of *Orion*. Up to the date of this discovery, all that was known of helium was that it caused a certain line to appear in the spectrum of the Sun.

The central range of buildings between the towers is devoted to laboratory rooms for astrophysical work. The flat roof of

THE 15-INCH EQUATORIAL REFRACTOR.
Royal Observatory, Edinburgh.

this portion of the building facilitates communication between the domes, and affords room for numerous meteorological instruments. On the main floor, beginning at the west end, are, (1) the spectroscopic room, to the south of which, outside the building, is placed a heliostat, by which the Sun's rays are reflected into the apartment through a 10-inch aperture; (2) the experimenting room, shown in one of our illustrations, which has three isolated pillars, supporting the mean time clocks, the dividing engine, the photographic measuring engine, and other instruments for delicate measuring operations; (3) the electric room, containing the large stock of electrical apparatus from the Dun Echt Observatory, the meteorological registering apparatus, etc., and (4) a mechanic's workshop and the chronograph room. The basement is occupied by stores, workshops, and printing room.

Southward from the central building extends a wing, 80 feet long, 28 feet wide, and having three floors. The basement floor is occupied by the heating plant and rooms for the electric dynamos and accumulators. The principal floor contains the CRAWFORD Library, one of the finest astronomical libraries in the world. Its shelves are specially rich in cometary literature. They contain, also, sets of the scientific publications of most of the astronomical societies and observatories in the world, the majority of the sets being complete from their beginning. Besides the library, this floor contains the Director's rooms and computing rooms. The top floor is one long apartment, used in connection with the 14-inch FOUCAULT siderostat, the hut containing which may be noticed on the central roof in both of the accompanying exterior views.

Eighty feet west from the main building and in line with the northwest front is placed the transit house, which is connected with the main building by a covered way. Here is placed the meridian circle from the Dun Echt Observatory, with telescope of 8.6 inches aperture, and the necessary collimators. This instrument is not exceeded in size and power by any in the world.

In addition to these instruments the observatory is supplied with a magnificent collection of minor instruments, so that it is completely equipped for the most thorough and advanced astronomical work, and ranks easily as an observatory of the first class.

A NEW VARIABLE STAR.

By Torvald Köhl.

The star No. 121 in Birmingham's Catalogue, = No. 144 in Chandler's Catalogue of red stars,—position for 1875.0: $5^h\ 38^m\ 12^s.47\ (+3^s.57),\ +20^\circ\ 38'\ 24''.9\ (+1''.9)$—has shown a remarkable change in brightness. It has formerly been estimated as a star of the 7.5th magnitude (B. D. has 7.7, Berlin A. G. Catalogue has 7.2). Dreyer observed it at Dublin from 1875 to 1879, and I at Odder from 1887 to 1893, without seeing any change of light in this orange-red star until on January 22, 1898, when I was surprised at the faintness of the star, which is now of about the 9th magnitude, and thus it has also been seen on the dates January 27 and 31 and February 1, 1898.

Odder, Denmark, February 6, 1898.

MAGNIFYING RATIOS OF EWING SEISMOGRAPHS OF THREE COMPONENTS, AND OF THE DUPLEX-PENDULUM SEISMOGRAPHS.

By C. D. Perrine.

In the following deductions the pen and plate are assumed to move with respect to the steady-point, and the motions of each are considered separately. In the reduction of the recorded displacements given by the pens upon the smoked glass plate, to the actual displacement of the Earth particle, there are several circumstances to be taken into account. In the case of the two horizontal components there are four considerations, viz:—

A.—The ratio of the pens, *i. e.* the distance from the point of the pen to the steady-point, divided by the distance from the steady-point to the point of support.

B.—The angle which the meridian of the pens makes with the true meridian of the place. If they coincide, there is no factor to be introduced on that account.

C.—The angle which a radius of the circular plate drawn through the point of the pen makes with a line drawn through

THE 24-INCH NEWTONIAN REFLECTING TELESCOPE.
Royal Observatory, Edinburgh.

the point of the pen and the steady-point. If this angle is ninety degrees, there is no factor to be introduced on this account.

D.—The effect on the record caused by the motion of the record-plate itself, due to the earthquake.

Let a = the record of the N. and S. pen as it appears upon the plate.

b = the record of the E. and W. pen as it appears upon the plate.

d = distance from steady-point to point of support of pendulum.

e = distance from steady-point tq point of pen.

$r = \frac{e}{d}$.

x = angle which the meridian of the pendulums makes with the true meridian of the place.

y and y' = angle between the direction of the pen-arm and a radius of the plate drawn through its point for the N. and S. and E. and W. pens, respectively.

z = angle which the radius of the plate drawn through the point of the pen makes with the true meridian of the place.

α = actual displacement of the Earth N. and S.

β = actual displacement of the Earth E. and W.

A.—The ratio of the pens is the ratio of the distances from the steady-point to the point of the pen, and from the steady-point to the point of support—in the instruments we are especially considering, the line joining the steel points which bear in the agate cups. Theoretically, the steady-point, or rather line, is the vertical line through the cylindrical weight about which the force of gravity is symmetrical. Practically, there is a little uncertainty as to the exact location of the steady-point — which, however, will be very near the axis of the cylindrical weight.

This ratio is given by the formula:—

$$r = \frac{e}{d}.$$

B.—The horizontal pendulums should be so adjusted that their meridian coincides with the true meridian of the place, *i. e.* that the plane (q) passing through the points of support and the steady-point of the pendulum, in the case of the E. and W. pendulum, should coincide with the meridian; in the N. and S. pendulum, this plane should lie E. and W.

If, however, there is no such coincidence, and the meridian of

the instruments makes an appreciable angle (x) with the true meridian, then the displacements of the pendulums in the true co-ordinates by the earthquake will vary with this angle. If the direction of the Earth's motion which it is designed to register is not *normal* to the plane (q), then the recorded motion will be less than it should be in the ratio of cos x : 1.

C.—If the horizontal pens are so situated that when at rest the radii of the plate passing through their points are tangent to the arcs described by them, then no factor is to be introduced on this account. Otherwise the displacement measured on such a radius will be too small in the proportion cos y : 1.

D.—The plate upon which the record is made is, of course, carried about by the Earth in its movements, which must be taken into account in deducing the actual motion of the Earth from the records of the pens.

In horizontal pendulums where the angle (p) between the lines drawn from the steady-point to the point of the pen, and from the steady-point to the point of support, is greater than ninety degrees, it can be shown that the *motion of the plate* due to the earthquake will be *additive* to the *pen's motion*, thus *increasing* the *record* of the pen, the plate being carried under the pen in an opposite direction to that in which the pen is moving. On the other hand, if the angle (p) is less than ninety degrees, the effect will be the opposite, *i. e.* to *decrease* the pen's record. This assumes that the pendulums are not *far* out of adjustment with respect to their meridians. In the Lick Observatory instruments the angle (p) is greater than ninety degrees, hence the effect is to *increase* the record. This is true for both co-ordinates.

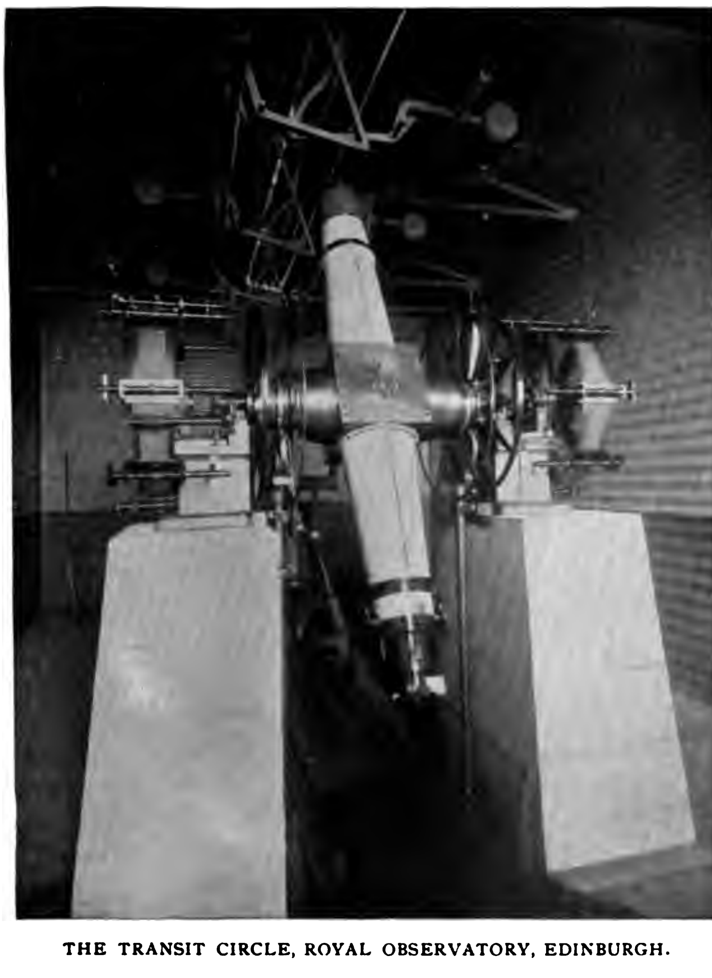
The component motion of the *plate* N. and S. as projected on a radius depends upon the angle (z) which that particular radius makes with the meridian, and varies as the *cosine* of that angle.

The component motion of the *plate* E. and W. as projected on the radius passing through the point of the E. and W. pen will vary as the *sine* of the angle (z).

From the foregoing we deduce the following formulæ for the reduction of the observed records to the true displacements of the Earth:—

$$\frac{a}{\alpha} = \frac{e \cos x \sin y}{d} \pm \cos z, \qquad (1.)$$

$$\frac{b}{\beta} = \frac{e \cos x \sin y'}{d} \pm \sin z. \qquad (2.)$$



THE TRANSIT CIRCLE, ROYAL OBSERVATORY, EDINBURGH.

Professor SCHAEBERLE suggests that we may also consider the plate and supports of the pens as one rigid system, and the steady-point to move with respect to this system.

Let f = distance from point of pen to point of support of pendulum, and, as before, d = distance from steady-point to point of support of pendulum.

Then, on the above assumption, it can be shown that,

$$\frac{a}{\alpha} = \frac{b}{\beta} = \frac{f}{d}, \qquad (3.)$$

so long as the instrumental meridian coincides with the true meridian of the station, and the radius of the plate passing through the points of the pens is normal to the lines passing through the points of the pens and their points of support. If, however, the instrument is not in adjustment in these two particulars, due allowance must be made for such variations.

THE VERTICAL COMPONENT.

In the mechanism for recording the Earth's vertical motion, the pen proper is jointed to a vertical arm, which in turn is fastened rigidly to the counterpoised pendulum. The lifting by the Earth causes the joint between the pen-arm and the vertical arm to be displaced in the arc of a circle, whose center is the steady-point of the pendulum. This displacement is resolved into a *horizontal* component (s), which leads to the magnified record on the plate, and a *vertical* component (t).

Let h = distance from steady-point to point where pen-arm is hinged to vertical arm.

i = distance from point of support to hinge of pen-arm.

j = distance from steady-point to point of support of pendulum.

m = angular displacement of the hinge of pen-arm from the steady-point as a center.

n = angle included between the lines drawn from pen-arm hinge to steady-point, and from pen-arm hinge to point of support of pendulum.

s = horizontal component of the displacement of pen-arm hinge.

t = vertical component of the displacement of pen-arm hinge.

γ = vertical displacement of the Earth.

c = the record of the vertical pen as it appears upon the plate.

m and n are found from

$$\sin m = \frac{\gamma}{j}, \qquad (4.)$$

$$\tan n = \frac{j}{i}, \qquad (5.)$$

and we find s and t from

$$s = \frac{h \sin m}{\cos \frac{1}{2} m} \cos (\tfrac{1}{2} m + n), \qquad (6.)$$

$$t = \frac{h \sin m}{\cos \frac{1}{2} m} \sin (\tfrac{1}{2} m + n), \qquad (7.)$$

For ordinary displacements of the Earth (m being always small) we may write (6.) and (7.) in the following forms:—

$$s = h \sin m \cos n, \qquad (8.)$$

$$t = h \sin m \sin n, \qquad (9.)$$

It will be seen that the pen-arm hinge is lifted a little ***higher*** by the Earth's motion than the plate itself. This causes the pen's record on the plate to be *shortened* slightly.

In a seismograph of the usual form the dimensions are such that so long as the pen-arm makes but a small angle with the plane of the plate, this factor will be small.

To compute the amount of this shortening, we have the following quantities in a right triangle.

a' = distance from point of pen to hinge of pen-arm = hypothenuse.

b' = perpendicular let fall from hinge of pen-arm to plate.

c' = distance from pen's point to foot of perpendicular = base of triangle.

A', B', C' = angles opposite given sides respectively, A' being the right angle.

We find B' from

$$\sin B' = \frac{b'}{a'}, \qquad (10.)$$

and we have (approximately)

$$\Delta c' = - \frac{\cos C' \, \Delta b'}{\cos B'}, \qquad (11.)$$

in which $\Delta c'$ is the decrease in the *record* due to the increase ($\Delta b'$) in the distance from pen-arm hinge to plate as a result of the lifting of the instrument by the shock.

For the Lick Observatory instrument we have:—

$a' = 5^{\text{in}}.75,$

$b' = 1^{\text{in}}.75,$

Using this data, I have computed the shortening of the *record* due to this cause, and find it to be only $0^{\text{in}}.014$ for a vertical motion of the Earth of $0^{\text{in}}.50$. Hence it will be seen that for shocks likely to be observed with these instruments, this effect may be ignored without sensible error.

If in equation (8.) we substitute for h cos n its equivalent i, and for sin m its equivalent $\frac{\gamma}{j}$ we find (approximately),

$$\frac{s}{\gamma} = \frac{i}{j}.$$

It can be shown that the same result follows from considering the motion to be about the support of the pendulum as the axis.

Finally we have for the magnifying ratio of the vertical pen,

$$\frac{c}{\gamma} = \frac{s}{\gamma} + \Delta\ c', \qquad (12.)$$

in which $\Delta\ c'$ may be neglected, as shown, or with sufficient accuracy,

$$\frac{c}{\gamma} = \frac{i}{j}, \qquad (13.)$$

For the Lick Observatory instruments we have the following data:—

$d = 3.75$ inches,
$e = 13.0$ inches,
$x = 6°$,
$y = 105°$,
$y' = 76°$,
$z = 38°.5$,
$h = 10.3$ inches,
$i = 9.0$ inches,
$j = 5.0$ inches,

from which we derive the following ratios:—

$$\frac{a}{\alpha} = 4.11, \qquad \text{(N. and S.)}$$

$$\frac{b}{\beta} = 3.97, \qquad \text{(E. and W.)}$$

$$\frac{c}{\gamma} = 1.8. \qquad \text{(Vertical.)}$$

The date given above and the constants deduced from them are suitable for the reduction of observations from April, 1893, to date.

MAGNIFYING RATIO OF THE DUPLEX SEISMOGRAPH.

In the ordinary form of this instrument there are two circumstances to be considered as affecting the magnification of the Earth's motion, viz:—

1st. The magnifying ratio of the vertical arm which is given by

$$\frac{a''}{b''},$$

in which

a'' = distance from lower end of vertical arm to level of glass plate;

b'' = distance from lower end of vertical arm to gimbal joint of bracket.

2d. The motion of the plate itself during the shock. It can be shown that the motion of the plate itself tends to decrease the *record* by the amount of the Earth's motion. Hence we have the following formula for the magnification:—

$$\frac{a''-b''}{b''}, \qquad (14.)$$

In the Lick Observatory instrument of this class we have,

$$a'' = 13^{\text{in}}.10,$$
$$b'' = 2\ .35,$$

and consequently the magnifying ratio = 4.6.

Owing to uncertainties, such as the friction of the pen upon the plate, the friction of the pendulums at the point of support, the probable motion of the steady-point itself after a few seconds, and other minor causes, it is not necessary to take into account all the lesser factors affecting the magnification of the record. All that is here attempted is to include those which have a practical effect. I have not been able to find the formulæ for these reductions in any publication on the subject here.

MT. HAMILTON, CAL., March 14, 1898.

VERY BRIGHT METEOR, MARCH 4, 1898.

OBSERVED BY H. D. CURTIS.

A very bright meteor was observed at College Park, March 4, 1898, $9^h\ 50^m\ 30^s$ P. S. T., moving from $\alpha = 13^h\ 40^m$, $\delta = +25°$ to $\alpha = 15^h\ 40^m$, $\delta = +40°$. Its path lay through the constellation *Bootes*, between the stars β and δ. At a point just a little west of the line joining these two stars, there was a small but abrupt angle in its path, inclining towards the south. Several small meteors passed in almost exactly the same track during the next hour.

ELEMENTS AND EPHEMERIS OF COMET *b*, 1898 (PERRINE).

BY R. T. CRAWFORD AND H. K. PALMER.

The following results were obtained from Mount Hamilton observations of March 20th and 22d and an observation taken at Berkeley on March 23d:—

$$T = \text{March } 19.0580, \text{ G. M. T.}$$

$$\left.\begin{aligned} i &= \ \ 72°\ 51'\ 42'' \\ \Omega &= 263\ \ 15\ \ 31 \\ \omega &= \ \ 49\ \ 28\ \ 52 \end{aligned}\right\} \text{Mean Equinox } 1898.0.$$

$$q = 1.1021.$$

$$(\text{O.—C.})\ \Delta\lambda \cos\beta = -4''.7 \quad \Delta\beta = +4''.7.$$

Constants to the equator:—

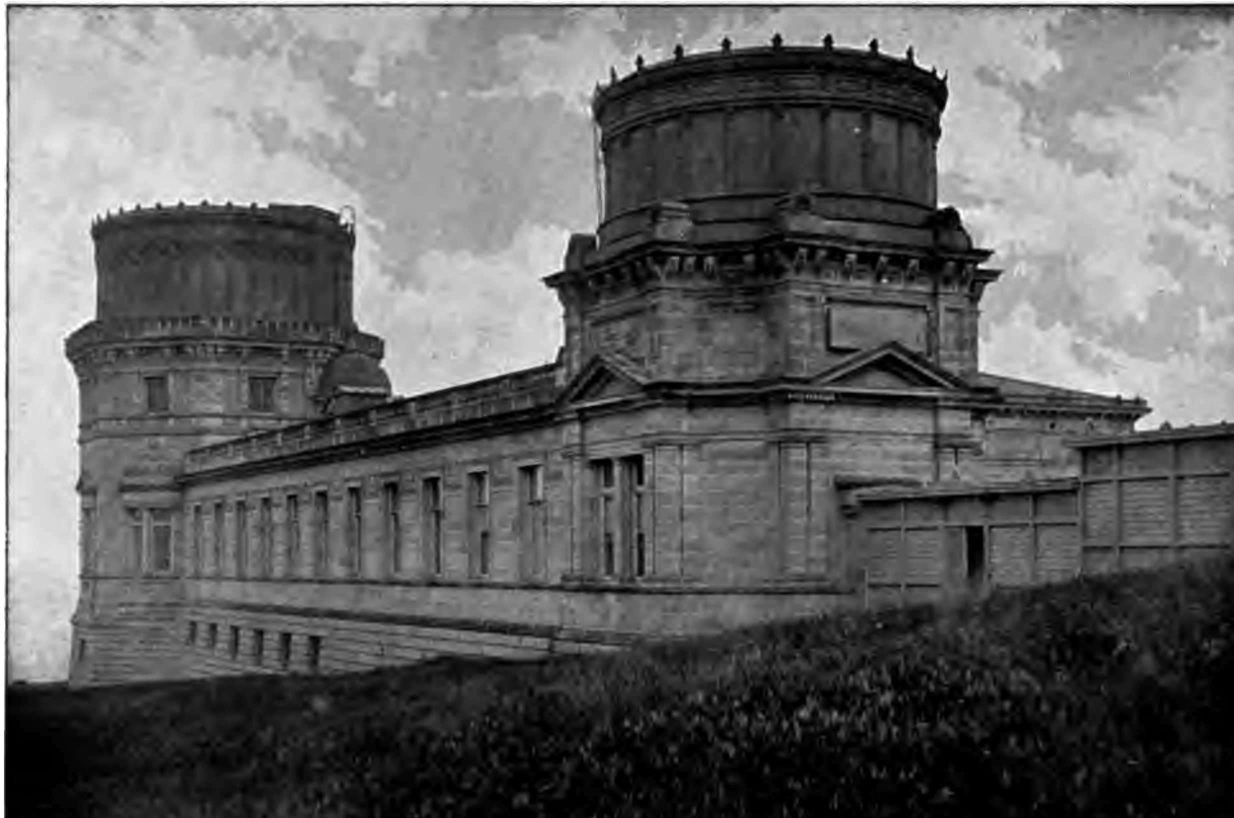
$$x = [9.54097] \sin(\ 27°\ 37'\ 25'' + v) \sec^2 \tfrac{1}{2} v.$$
$$y = [0.04218] \sin(295\ \ 8\ \ 42 + v) \sec^2 \tfrac{1}{2} v.$$
$$z = [0.01954] \sin(\ 24\ \ 52\ \ 17 + v) \sec^2 \tfrac{1}{2} v.$$

Ephemeris (Gr. Mean Midnight):—

1898.	App. α.	App. δ.	Brightness.
March 29.5	$21^h\ 55^m\ 9^s$	$+26°\ 29'\ 29''$	0.99
April 2.5	22 12 4	30 26 49	0.96
6.5	22 29 56	34 12 41	0.91
10.5	22 48 45	37 43 53	0.86

The brightness is expressed in terms of the brightness at the time of discovery.

University of California,
Students' Observatory, March, 1898.



NORTH FRONT OF THE ROYAL OBSERVATORY, EDINBURGH.

NOTICES FROM THE LICK OBSERVATORY.*

PREPARED BY MEMBERS OF THE STAFF.

A LUNAR LANDSCAPE, PHOTOGRAPHED AT THE LICK OBSERVATORY.

The original negative from which the Moon-plate (given in the present number of our *Publications*) was made, was taken on December 31, 1897, with an enlarging lens, (magnifying the principal focal image eight diameters), attached to the 36-inch refractor.

The exposure time was from $7^h\ 58^m\ 30^s$ to $7^h\ 58^m\ 50^s$, P. S. T. The error in the clock-rate and the motion in declination were counteracted by giving to the plate a single uniform motion by means of a screw turned by hand, the required velocity and direction of motion having first been determined by actual observation of the enlarged focal image.

The scale of the published plate (Moon's diameter = 40 inches) is the same as that of the original negative.

We have satisfactorily enlarged portions of some of our negatives to a scale of sixty feet to the Moon's diameter.

J. M. S. and C. D. P.

THE LICK OBSERVATORY ECLIPSE EXPEDITION.

[Extracts from a letter by Professor W. W. CAMPBELL.]

"The story of the eclipse is too long to tell in a letter. I had to locate in *level country*, in a *famine district*, *water scarce*, *dust plentiful*, the plague on both sides of us. There were no habitable buildings nearer than fifteen miles, so camping was a matter of necessity. The difficulties were great, but I kept my

* Lick Astronomical Department of the University of California.

courage up, and was all ready for the eclipse on January 16th. The assistants—fine ones—arrived from January 17th to 20th, and were drilled to the work. There had not been a cloud in the sky for six weeks, and eclipse day was simply beautiful. The 'seeing' was fair that day, though it had been poor—Sun boiling—on all previous days.

"The eclipse began within half a second of my predicted chronometer time, and closed in the same manner. No wind existed, though I was prepared for wind. The corona had great extent, but was faint as a whole. The prominences were numerous, but vastly smaller than in 1893. The sky was *very*, *very* bright. Animals paid very little attention to the eclipse. Three miles away, on the horizon formed by a low ridge, I saw the small trees with perfect distinctness during totality.

"The 40-foot telescope gave—

1 instantaneous Seed 27 plates.
2 one-second " " "
2 two-second " " "
2 four-second " " "
2 eight-second " " "
1 sixteen-second " " " (defective plate).
1 instantaneous Carbutt B plate (very little on plate).
1 one-second " " (very little on plate, and was caught by the Sun).

"There were eight beautiful negatives with the Dallmeyer and with the Floyd. The spectrum of the Sun's edge was fainter than I expected, but the plates are pretty successful and valuable.

"But I'll save the rest of the story till I get home. I had a great struggle with the dust and the heat in developing the plates. I had to have the dark-room in a tent, temperature 94° Fahr. in the daytime. Had to wait till 1 A.M. to begin developing. And the dust was awful, too. The water was absolutely muddy—had to be boiled and filtered. I never saw such dry climate. Some days the dry bulb was $+32°$ C., and the wet bulb $+18°$ C., or even $+17°$ C. My hands were cracked wide open, and I could scarcely finish the development of the original plates, to say nothing of making copies."

These extracts from Professor CAMPBELL'S letter to Professor SCHAEBERLE are printed here, as they will be of general interest to the members of the Society. R. G. A.

THE COMPANIONS TO *ALDEBARAN*.

I have recently made the following set of measures of the two companions to *Aldebaran*:—

A and B = β 550.

1898.10	109°.7	31″.30	36-inch telescope	3 nights

A and C = Σ 2 (App. II).

1898.10	34°.3	117″.90	12-inch telescope	4 nights

C and D = β 1031.

1898.10	275°.2	1″.62	36-inch telescope	2 nights

These measures give additional confirmation to the conclusions stated by Mr. BURNHAM in 1891:† first, that the minute star "B" has the same proper motion as the principal star; the mean of five sets of measures of A and B, made by different observers between 1877 and 1891, is 109°.8 31″.08; second, that the HERSCHEL companion, C, has a proper motion of its own, differing from that of the principal star; third, that D, the companion to C, shares its proper motion, the relative change being due to some other cause. C and D, then, probably form a physical system, having no connection, other than optical, with A and B, and the apparent distance between the two systems will continually increase. R. G. AITKEN.

February 26, 1898.

A REMARKABLE OBJECT.

[*Wolsingham Observatory Circular*, No. 46.]

"A remarkable object, hitherto unrecorded, was discovered on January 16th, and seen on three other nights. It is elliptical, one degree long, major axis 336°, and rather resembles some obscuring medium than a nebula, and is, I believe, unique.

"Place: R. A. $4^h\ 26^m\ 0^s$, Decl. +50° 44′ (1855).

T. E. ESPIN."

1898, February 16.

REQUEST FOR OBSERVATIONS.

Mademoiselle VERÀ STACHEVITET, Observatoire d' École Superieure des Femmes, Île de Basil 10 Ligne d. 33, St. Petersburg, wishes to compute the definitive orbit of Comet 1896 I, and would like any unpublished observations sent to her. C. D. P.

† *Monthly Notices* R. A. S., March, 1891.

A Daylight Meteor.

"Director of Lick Observatory.

"Dear Sir: I saw by the papers that a meteor had lately been observed by one of your men, and thought it might be of interest to you to say that last October, about an hour before sunset, I observed a very large and brilliant meteor fall between this city and a mountain to the north, not more than fifteen miles away. It left behind a spiral-shaped cloud of smoke, which was visible for about twenty minutes. Yours truly, Chas. Pixley."

Missoula, Mont., January 24, 1898.

Missing Books.

The following books and periodicals are missing from the library of the Society, and no record of their whereabouts appears upon the charging book. Any information concerning them will be gratefully received by the Library Committee.

BOOKS.

No. 3. Proctor (R. A.): Other Worlds than Ours. 12mo.
9. Webb (T. W.): Celestial Objects for Common Telescopes. 12mo.
10. Webb (T. W.): Celestial Objects for Common Telescopes. 12mo.
17. Oliver (J. A. W., and others): Astronomy for Amateurs. 12mo.
18. Oliver (J. A. W., and others): Astronomy for Amateurs. 12mo.
46. Young (C. A.): The Sun. 12mo.
47. Young (C. A.): The Sun. 12mo.
49. Proctor (R. A.): Orbs Around Us. 12mo.
51. Kirkwood (D.): Meteoric Astronomy. 12mo.
57. Newcomb (S.): Popular Astronomy. 12mo.
252. Mueller (H.): *Die Kepler'schen Gesetze.* 8vo.
253. Prestel (M. A. F.): *Astronomisches Diagramm.* 8vo.
260. Thornton (J.) Physiography. 12mo.
277. Brewster (D.): More Worlds than One. 12mo.
281. ———: Martyrs of Science. 12mo.
282. ———: Life of Sir Isaac Newton. 12mo.
301. Lynn (W. T.): Celestial Motions. 16mo.
302. Johnson (S. J.): Eclipses, Past and Future. 16mo.

318. SCHELLEN (H.): Spectrum Analysis. 8vo.
322. LEDGER (E.): The Sun, Its Planets, etc. 12mo.
330. LEWIS (S. C.): Historical Survey of the Astronomy of the Ancients. 8vo.
489. PROCTOR (R. A.): Myths and Marvels of Astronomy. 12mo.

PERIODICALS.

The Observatory: No. 252 (April, 1897).
Monthly Notices Royal Astronomical Society: Vol. LVI, Nos. 2, 4, 5.
The Astrophysical Journal: Vol. V, Nos. 2, 4, 6; Vol. 6, No. 1.

THE LIBRARY COMMITTEE.

ELECTION OF PROFESSOR JAMES E. KEELER AS DIRECTOR OF THE LICK OBSERVATORY.

At the regular meeting of the Board of Regents of the University of California, held in San Francisco on Tuesday, March 8, 1898, Professor JAMES E. KEELER, Director of the Allegheny Observatory, was chosen to fill the vacancy created by the resignation of Professor E. S. HOLDEN as Director of the Lick Observatory.

At this date it is not known when Professor KEELER will assume the duties of his new office. R. G. AITKEN.

March 16, 1898.

LIBRARY NOTICE.

Attention is called to the report of the Library Committee printed in this number in the minutes of the meeting of the Board of Directors. The Committee is making every effort to increase the value and usefulness of the library, both by adding to the number of volumes and by making these more easily accessible. It is especially desirable to increase the number of books and periodicals of large popular interest. Contributions of this class from any source will be thankfully received.

PUBLICATION COMMITTEE.

DISCOVERY OF COMET *b*, 1898 (PERRINE).

This comet was discovered in the morning of March 20th. At $0^h\ 53^m\ 56^s$ G. M. T. its position was R. A. $21^h\ 18^m\ 36^s.89$, and Decl. $+16°\ 43'\ 23''.3$. It was then very near the western

limits of the constellation *Pegasus*, a little south and west of the star *iota*. Its daily motion is north 1° and east about the same amount.

The head is composed of a nucleus, some 10″ in diameter, surrounded symmetrically by a nebulosity 2′ in diameter. The nucleus does not present a stellar appearance, but looks granular.

Extending away from the comet, in position-angle 281°, is a moderately broad tail, which can be traced to a distance of 1°. It seems to broaden near the end, and there are indications of a fainter nebulosity surrounding the main tail.

The head of the comet is about as bright as a seventh magnitude star, and can be seen with a very small telescope.

MT. HAMILTON, Cal., March 21, 1898. C. D. P.

ELEMENTS OF COMET *b*, 1898 (PERRINE).

From Mr. PERRINE'S observation of March 19th, at the time of discovery, and my observations of March 21st and 22d, I have computed the following elements of this comet:—

$$T = \text{March } 19.1079, \text{ G. M. T.}$$

$$\left.\begin{aligned} \omega &= 49^\circ\ 31'\ 16'' \\ \Omega &= 263\ \ 19\ \ 53 \\ i &= 72\ \ 53\ \ 25 \end{aligned}\right\} \begin{array}{c}\text{Ecliptic and}\\ \text{Mean Equinox of 1898.0.}\end{array}$$

$$\log q = 0.04252.$$

$$(\text{O.}-\text{C.})\ \Delta\lambda' \cos\beta' = +5'' \qquad \Delta\beta' = +3''$$

W. J. HUSSEY.

ASTRONOMICAL TELEGRAMS (*Translation*).

Lick Observatory, March 20, 1898.

To Harvard College Observatory,
Students' Observatory. } Sent $12^h\ 35^m$ P. M.

A bright comet was discovered by C. D. PERRINE (on March 20th, at 4:30 A.M.). Its position, March 20th, $0^h\ 53^m\ 56^s$ G. M. T., was, R. A. $21^h\ 18^m\ 36^s.89$; Decl. $+16^\circ\ 43'\ 23''.3$. Its daily motions are $+56'$ in R. A. and $+61'$ in Decl. The physical appearance of the comet is, nebulosity 2′ diameter, seventh magnitude, strong central condensation, tail 1° long.

Lick Observatory, March 22, 1898.

To Harvard College Observatory:
To Students' Observatory, Berkeley: } (Sent 10:15 A.M.)

Comet *b*, 1898, (PERRINE) was observed by W. J. HUSSEY, March 22.0532, G. M. T.; R. A. $21^h\ 25^m\ 59^s.8$, Decl. $+18^\circ\ 49'\ 17''$.

Lick Observatory, March 23, 1898.

To Harvard College Observatory:
To Students' Observatory, Berkeley: } (Sent 9:55 A.M.)

Comet *b*, 1898, (PERRINE) was observed by C. D. PERRINE, March 22.9855, G. M. T.; R. A. $21^h 29^m 28^s.9$, Decl. $+19° 47' 24''$.

Lick Observatory, March 23, 1898.

To Harvard College Observatory: (Sent 9:30 P.M.)

The following elements and ephemeris of Comet *b*, 1898, (PERRINE) were computed by W. J. HUSSEY and C. D. PERRINE:—

$T =$ 1898, March 18.67, G. M. T.
$\omega = 49° \; 2'$
$\Omega = 264 \quad 7$
$i = 72 \quad 48$
$q = 1.1013.$

[The ephemeris is omitted here.]

ERRATUM.

Volume X, page 35, line 3, *for* 1897 *read* 1898.

THE CRAWFORD LIBRARY, ROYAL OBSERVATORY, EDINBURGH

Minutes of the Special Meeting of the Board of Directors of the Astronomical Society of the Pacific, held in the Rooms of the Society, on Saturday, November 27, 1897, at 2 P.M.

Mr. Pierson presided. A quorum was present.

The purpose of the meeting being the First Award of the Bruce Gold Medal, the letters received from the Directors of the six nominating Observatories were submitted by the Secretary. After a careful consideration of the recommendations contained in these letters, the selection of the Medalist was made by ballot, and the following certificate of bestowal was signed by all Directors present:—

San Francisco, November 27, 1897.

First Award of the Bruce Medal.

We, the undersigned Directors of the Astronomical Society of the Pacific, hereby certify, that, in accordance with the Statutes for the bestowal of the Bruce Medal, a special meeting of the Board of Directors was held this day, at 2 o'clock P. M., for the purpose of awarding the medal for the year 1898; and that, the provisions of the Statutes relating to its bestowal having been complied with, the medal was awarded to—

SIMON NEWCOMB

for Distinguished Services to Astronomy, by the consenting votes of eight Directors.

Signed: Wm. M. Pierson, Frederick H. Seares, Fremont Morse, Rose O'Halloran, C. D. Perrine, F. R. Ziel, E. S. Holden (by proxy), C. M. St. John (by proxy).

Adjourned.

On January 1, 1898, the Secretary addressed a letter to Professor Newcomb, notifying him of the action taken by the Directors. The following letter of acceptance was received on January 17th:—

Washington, January 11, 1898.

Mr. F. R. Ziel, *Secretary.*

Dear Sir: I have the honor to acknowledge receipt of your communication of the 1st inst., apprising me that the Board of Directors of the Astronomical Society of the Pacific had awarded me the first Bruce Gold Medal, being that for the year 1898. It gratifies me extremely to know that this should have been the result of so admirable a method of selection as that prescribed in your statutes. I beg that you will assure the Board of Directors of my very high appreciation of such an honor from my own Country, and of the pleasure with which I signify my acceptance.

Yours most respectfully,

Signed: Simon Newcomb.

Minutes of the Meeting of the Board of Directors, held in the Rooms of the Society, March 26, 1898, at 7:30 p. m.

Miss O'Halloran presided. A quorum was present. The minutes of the last meeting were read and approved. The following members were duly elected:—

List of Members Elected March 26, 1898.

Mr. W. W. Allen	Pueblo Smelting and Refining Co., Pueblo, Colo.
Mr. Manley F. Bendall	15 Rue de Tivoli, Bordeaux France.
Mr. John Everding, Jr.	48 Clay St., S. F., Cal.
Mr. J. H. Firehammer	1590 Pacific Ave., Alameda, Cal.
Miss Adelaide M. Hobe	604 Capp St., S. F., Cal.
Mr. Harold K. Palmer	Berkeley, Cal.

The Library Committee presented its report, as follows, and the report was, on motion, adopted and filed:—

Report of the Committee on the Library, Submitted March 26, 1898.

To the Board of Directors of the Astronomical Society of the Pacific:

Gentlemen—We, the undersigned, Committee on the Society's Library, respectfully report as follows:—

During the year the library has been reaccessioned, and the construction of a card catalogue has been undertaken. The bound books have been classified on the shelves according to subject; the unbound books and pamphlets have been similarly classified and arranged in drawers specially provided for the purpose. A large amount of binding has been done, and considerable purchases of books have been made. Through binding and purchase, together with gifts from corresponding institutions, 290 volumes have been added to the shelves.

The library consists at present of about 910 bound volumes and several hundred pamphlets. Exact numbers cannot be given until the work of cataloguing has been finished.

The purchases have been made in pursuance of the recommendation contained in the report of the Library Committee for the year 1890–91 (*Publications* A. S. P., Vol. III, page 149), as follows: "Your committee . . . would recommend that hereafter the revenue derived from the remainder of the Alexander Montgomery Fund should be applied to the purchase of the more technical and recondite works on astronomy." While acting in accordance with this recommendation, the present Library Committee has, nevertheless, felt that the library should also secure, as largely and as rapidly as possible, the astronomical works of greater popular interest. Gifts of single books or of sets of books of this class are especially desired.

During the past year special effort has been made to secure for the library valuable books which are out of print, and which are rapidly becoming rare.

The following is an account of the expenditures of the Alexander Montgomery Library Fund for the year ending March 26, 1898:—

1897, Aug.	24.	*Popular Astronomy*	$ 14 00
		Hicks-Judd Co. for binding 105 volumes	94 60
		Kreutz—missing numbers *Astron. Nachrichten*	1 90
		94 volumes of *Astronomische Nachrichten*	306 00
		Cable *re* 94 vols. *Astron. Nachrichten*	7 24
		Freight on 94 vols. *Astron. Nachrichten*	9 46
Sept.	1.	4 chests drawers for pamphlets	12 00
	15.	Freight on card catalogue from Chicago	2 90
	16.	Card catalogue, etc.	19 10
1898, Jan.	7.	Expressage on H. C. O. Annals from Cambridge	5 10
Feb.	14.	Hicks-Judd Co. for binding 38 volumes	32 80
Mar.	9.	3 volumes *Astronomical Journal*	7 50
			$ 512 60

Respectfully submitted,

William J. Hussey,
Frederick H. Seares,
Rose O'Halloran,

Committee.

Minutes of the (Adjourned) Annual Meeting of the Astronomical Society of the Pacific, held in the Rooms of the Society, April 2, 1898, at 8 P. M.

The meeting was called to order by Mr. Pierson. A quorum was present. The minutes of the last meeting were approved.

The Secretary read the names of new members duly elected at the Directors' meeting of March 26, 1898.

The following papers were presented:—

1. Address of the retiring President, by Hon. William Alvord.
2. Reports of Committees: on Nominations; on the Comet-Medal; on the Library; on Auditing; and Annual Report of the Treasurer.
3. The Edinburgh Observatory, by Professor R. G. Aitken.
4. Earthquakes in California in 1897, by Mr. C. D. Perrine.
5. A New Variable Star, by Mr. Torvald Köhl, of Odder, Denmark.
6. Latitude Work with the Fauth Transit of the Lick Observatory, by Professor H. D. Curtis.
7. Planetary Phenomena for May and June, 1898, by Professor M. McNeill.
8. Magnifying Ratios of Ewing Seismographs of Three Components, and of the Duplex-Pendulum Seismographs, by Mr. C. D. Perrine.

The Committee on Nominations reported a list of names proposed for election as Directors, as follows: Messrs. R. G. Aitken, C. B. Hill, James E. Keeler, E. J. Molera, C. D. Perrine, Wm. M. Pierson, F. H. Seares, C. M. St. John, O. von Geldern, F. R. Ziel, and Miss R. O'Halloran.

For Committee on Publication: Messrs. R. G. Aitken, F. H. Seares, O. von Geldern.

Messrs. Cushing and Moses were appointed as tellers. The polls were open from 8:15 to 9 p. m., and the persons above named were duly elected to serve for the ensuing year.

Report of the Committee on the Comet-Medal, Submitted March 26, 1898.

The present report relates to the calendar year 1897. The comets of 1897 are:—

Comet *a* (d'Arrest's periodic comet), rediscovered June 28, by C. D. Perrine, Assistant Astronomer in the Lick Observatory.

Comet *b* (unexpected comet), discovered October 16, by C. D. Perrine, Assistant Astronomer in the Lick Observatory.

The Comet-Medal of the Society has been awarded to Mr. Perrine for the discovery of Comet *b*. This is the fifth award (made for similar previous discoveries) to the same observer.

Respectfully submitted,

E. S. Holden,
J. M. Schaeberle,
W. W. Campbell.

The Treasurer submitted his Annual Report, as follows:—

Annual Statement of the Receipts and Expenditures of the Astronomical Society of the Pacific for the Fiscal Year ending March 26, 1898.

GENERAL FUND.

Receipts.

Cash Balance, March 28, 1897		$ 489 29
Received from dues	$1471 67	
" " sale of publications	69 35	
" " " " stationery	1 50	
" " " " furniture, etc.	12 00	
" " advertisements	63 25	
" " Security Savings Bank (interest)	4 37	
" " Life Membership Fund (interest)	73 49	
	$1695 63	
Less transfer to Life Membership Fund	450 00	$1245 63
		$1734 92

Expenditures.

For publications	$ 722 10	
" general expenses	624 04	
		$1346 14
Cash Balance March 26, 1898		388 78
		$1734 92

LIFE MEMBERSHIP FUND.

Cash Balance March 28, 1897	$1750 61	
Received from General Fund	450 00	
" " interest	73 49	
	$2274 10	
Less interest transferred to General Fund	73 49	
Cash Balance March 26, 1898		$2200 61

DONOHOE COMET-MEDAL FUND.

Cash Balance March 28, 1897	$ 676 04	
Interest	26 21	
	$ 702 25	
Less transfer to Montgomery Library Fund (see Vol. IX, page 113)	70 89	
Cash Balance March 26, 1898		$ 631 36

ALEXANDER MONTGOMERY LIBRARY FUND.

Cash Balance March 28, 1897	$1932 68	
Interest	71 12	
Transfer from Comet-Medal Fund (see Vol. IX, page 113)	70 89	
	$2074 69	
Less expended for books, binding, etc.	512 60	
Cash Balance March 26, 1898		$1562 06

BRUCE MEDAL FUND.

Sept. 20, 1897. Cash received from Miss C. W. Bruce	$2750 00	
Interest	18 30	
Cash Balance March 26, 1898		$2768 3

FUNDS.

Balances on Deposit as follows:

General Fund:			
	with Donohoe-Kelly Banking Co.	$ 330 45	
	" Security Savings Bank	58 33	
			$ 388 78
Life Membership Fund:			
	with San Francisco Savings Union	$1000 61	
	" German Savings and Loan Society	600 00	
	" Hibernia Savings and Loan Society	600 00	
			$2200 61
Donohoe Comet-Medal Fund:			
	with San Francisco Savings Union	$ 205 34	
	" German Savings and Loan Society	213 36	
	" Hibernia Savings and Loan Society	212 66	
			$ 631 36
Alexander Montgomery Library Fund:			
	with San Francisco Savings Union	$528 55	
	" German Savings and Loan Society	421 36	
	" Hibernia Savings and Loan Society	612 18	
			$1562 09
Bruce Medal Fund:			
	with San Francisco Savings Union	$1510 06	
	" Security Savings Bank	628 99	
	" German Savings and Loan Society	629 25	
			$2768 30
			$7551 14

SAN FRANCISCO, March 26, 1898. F. R. ZIEL, *Treasurer.*

The committee appointed to audit the Treasurer's accounts reported as follows, and the report was, on motion, accepted and adopted:—

To the President and Members of the Astronomical Society of the Pacific:

GENTLEMEN—Your committee appointed to audit the accounts of the Treasurer for the fiscal year ending March 26, 1898, have made a careful examination, and find same to be correct.

Yours respectfully,

JOS. GASSMANN,
F. H. MCCONNELL.

In the absence of Mr. ALVORD, the address of the President was read by Mr. CUSHING.

The following resolution was, on motion, adopted:—

Resolved, That all the acts appearing in the minutes of the meetings of the Board of Directors of this Society, as having been done by said Board during the past fiscal year, are here now, by this Society, approved and confirmed.

Adjourned.

Minutes of the Meeting of the Board of Directors, held in the Rooms of the Society, April 2, 1898, at 9 P. M.

The new Board of Directors was called to order by Miss O'Halloran. A quorum was present. The minutes of the last meeting were approved.

The business in hand being the election of officers and committees for the ensuing year, the following officers and committees, having received a majority of the votes cast, were duly elected:—

President: Mr. R. G. Aitken.

First Vice-President: Mr. C. B. Hill.

Second Vice-President: Miss R. O'Halloran.

Third Vice-President: Mr. F. H. Seares.

Secretaries: Messrs. C. D. Perrine and F. R. Ziel.

Treasurer: Mr. F. R. Ziel.

Committee on the Comet-Medal: Messrs. Schaeberle (*ex-officio*), Pierson, Burckhalter.

Library Committee: Messrs. F. H. Seares, Geo. C. Edwards, Miss R. O'Halloran.

Mr. Seares was appointed Librarian.

The Chairman was authorized to appoint the members of the Finance Committee, and accordingly made the following selections:

Finance Committee: Messrs. Pierson, von Geldern, Hill.

The *Committee on Publication* is composed of:—
Messrs. Aitken, Seares, and von Geldern.

Adjourned.

OFFICERS OF THE SOCIETY.

Mr. R. G. AITKEN . . . . *President*
Mr. C. B. HILL . . . . *First Vice-President*
Miss R. O'HALLORAN . . . . *Second Vice-President*
Mr. F. H. SEARES . . . . *Third Vice-President*
Mr. C. D. PERRINE }
Mr. F. R. ZIEL } . . . . *Secretaries*
Mr. F. R. ZIEL . . . . *Treasurer*

Board of Directors—Messrs. AITKEN, HILL, KEELER, MOLERA, Miss O'HALLORAN, Messrs. PERRINE, PIERSON, SEARES, ST. JOHN, VON GELDERN, ZIEL.

Finance Committee—Messrs. PIERSON, VON GELDERN, HILL.

Committee on Publication—Messrs. AITKEN, SEARES, VON GELDERN.

Library Committee—Messrs. SEARES, GEO. C. EDWARDS, Miss O'HALLORAN.

Committee on the Comet-Medal—Messrs. SCHAEBERLE (*ex-officio*), PIERSON, BURCKHALTER.

OFFICERS OF THE CHICAGO SECTION.

Executive Committee—Mr. RUTHVEN W. PIKE.

OFFICERS OF THE MEXICAN SECTION.

Executive Committee—Mr. FRANCISCO RODRIGUEZ REY.

NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only. Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book-keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the *Publications* for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of two dollars per volume to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to the Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the card.

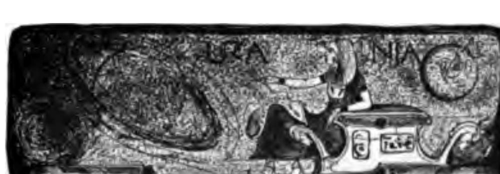
The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States. The responsibility for the views expressed in the papers printed rests with the writers, and is not assumed by the Society itself.

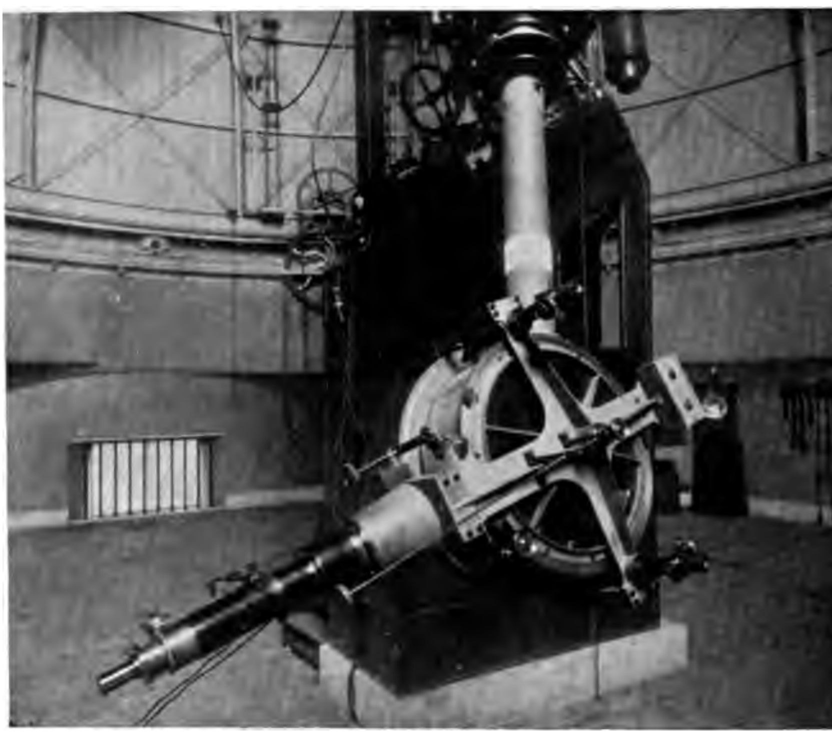
The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery, stamped with the seal of the Society, at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific" at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.

PUBLICATIONS ISSUED BI-MONTHLY.

(February, April, June, August, October, December.)





THE SPECTROSCOPE ATTACHED TO THE 15-INCH REFRACTOR OF THE ROYAL OBSERVATORY, EDINBURGH.

THE SOLAR CORONA OF JANUARY 22, 1898.

(Photographed with the Floyd telescope, by W. W. CAMPBELL.)

PUBLICATIONS

OF THE

Astronomical Society of the Pacific.

VOL. X. SAN FRANCISCO, CALIFORNIA, JUNE 1, 1898. NO. 62.

ON THE CAUSES OF THE SUN'S EQUATORIAL ACCELERATION AND THE SUN-SPOT PERIOD.

By E. J. WILCZYNSKI.

In the beginning of every science isolated facts present themselves, which apparently have no connection with each other. As the science is gradually perfected, relations are found between the different phenomena, the subject becomes more complex, and covers a wider stretch than it did at first; but at the same time it becomes easier to understand because it is found that all of the phenomena, which have been observed, are but the consequences of certain fundamental laws. In solar physics two laws of fundamental importance have been found, the law of the equatorial acceleration and that of the periodicity of sun-spots. Their great significance lies in this, that they give numerical relations between measurable quantities, and that their consequences can, therefore, be deduced by mathematical reasoning.

The researches which I have made upon this subject have appeared in my inaugural dissertation on "Hydrodynamische Untersuchungen mit Anwendungen auf die Theorie der Sonnenrotation," Berlin, 1897, and in some papers in the *Astrophysical Journal*. A brief account has also appeared in the *Astronomical Journal*, Vol. XVIII, No. 416. In this paper I will try to present the principal points in popular language.

We assume the Sun to be a fluid body, the general term fluid comprehending both gaseous and incompressible fluids as special cases. Its present condition and the present motion of its parts are, then, but the consequences of the condition of the nebula from which it has been formed, and of the motion of the parts of this

nebula. This is exactly the same as in the case of planetary orbits. The form of the planet's orbit and its position in space was determined by the position and the motion of the planet at the time of its formation. Such an orbit must be a conic section, if we neglect the perturbations, and it may possibly be a circle. And just in the same way as a circular orbit is an exception in the case of planetary orbits, only one occurring among an infinite number, so also is it infinitely improbable that a gaseous body starting to rotate should rotate in the same way as a solid mass. It may do so, but in general it will not.

But obviously we must take into account the influence of the internal fluid friction, which, of course, tends to make the body rotate as if it were solid. But the mathematical theory shows this influence to be very small, so small that it will not change the daily arc described by a point upon the Sun by 2′ in 27,500,000 years.

This result is obtained in the course of investigating the following problem. All particles of a viscous fluid describe circles in parallel planes around an axis perpendicular to these planes. The conditions for the motion and figure of such a body are investigated. The angular velocity of rotation is supposed to be different in different parts of the fluid. It is found that an important theorem holds, which we proceed to explain.

The density of the body, as well as the temperature may vary from point to point. All points in which the density has the same value constitute, in general, a surface which is called a surface of constant density. Similarly we can speak of surfaces of constant temperature. The theorem which we have in view is this:—

In a rotating viscous fluid, the angular velocity of rotation is the same for all points whose distance from the axis of rotation is the same, if the surfaces of constant density and of constant temperature coincide. If we conceive the axis of rotation to be surrounded by a family of co-axial cylinders, the surface of each cylinder rotates as if it were rigid.

This theorem is shown to be very probably true for the case of the Sun, and the surfaces of constant density are calculated approximately. By applying the theorem to the comparison of the different laws of rotation which have been empirically found for the sun-spots, for the faculæ and for the so-called reversing layer, the difference in level of these different solar strata can be

ascertained. The discussion of these numbers leads to the result that the solar atmosphere, i. e. the region above the "photosphere" is much more extensive than has usually been believed. The contradictions, which seem to rise herefrom at first sight, can be easily cleared up if the power of refraction, which this atmosphere must have, is taken into account. One other important conclusion is that the sun-spots must be higher up in the solar atmosphere than the photosphere, a view which, while opposed to the classical idea of WILSON, is nevertheless constantly gaining more adherents.

If the motion of the solar particles is not strictly uniform and circular, and it is easy to see that in general it will not be so, the deviations from the uniform circular motion cause corresponding changes in the temperature, pressure and density, as the equations show. Now it is quite easy to show that these deviations, supposed to be small in comparison with the principal motion, are of an oscillatory character, tending at the same time towards zero. That is, they will be periodic functions of the time but become constantly smaller, in the same way as a pendulum swinging in air oscillates backward and forward, but finally comes to a stop. But in our case this dampening effect is only very slight, and may not be noticed for thousands of years. To the periodic variations of the motion will then correspond periodic changes in temperature, etc., and it is extremely plausible that hereto will correspond periodic variations of the Sun's activity. This line of thought gives a very reasonable explanation of the sun-spot period, which is also supported by some numerical work which is meant to show that the causes invoked are sufficient to explain the observed phenomena.

If we remember that the theory sketched out here is based on no arbitrary assumptions, that it reaches its conclusions by rigid mathematical reasoning, and that it succeeds in uniting the observations of solar physicists, which have been the source of so many wild hypotheses, into one consistent whole, it certainly seems to be a step in the right direction. And it seems to me that we are justified in saying that the rotation-law is the instrument with which to fathom the solar mysteries. It is the fundamental law to which all others, even that of the sun-spot period, are but supplementary.

Nautical Almanac Office,
WASHINGTON, D. C., May 6, 1898.

THE NEW ATLAS OF VARIABLE STARS.*

By the Rev. Father J. G. Hagen, S. J.

Dear Sir:—In compliance with your kind invitation to send to you a description of the forthcoming Atlas of Variable Stars, I offer the following remarks on the plan of the work, on the observations, and on the construction of the charts:—

I. The Atlas is *planned* to contain all variable stars from the north pole to $-25°$ Declination. For the present are excluded the the new stars, called *Novæ*, and the recently discovered stars, whose variability and character are not yet sufficiently established.

The Atlas is divided into five *Series*, the first three of which comprise those Variables that fall below the 10th magnitude at their minimum phase, while the fourth series contains those that can be followed with a three-inch telescope throughout their entire variation, and the fifth gives all the naked-eye Variables. The first three Series cover respectively the zones from $-25°$ to the equator, from the equator to $+25°$ and from $+25°$ to the pole. Arrangements have been made with the publisher by which each of the five series can be procured separately, so that observers will be enabled to select for themselves that Series which best suits their equipment and their location with regard to the equator. Beginners especially will find this division of the whole Atlas advantageous, as they will have the whole program of their work marked out, without the danger of omitting interesting variables or of wasting time upon unsuitable objects.

The following description is confined to the first three Series, as the fourth and fifth will require special explanations.

II. The *observations* for the first three Series were the most laborious, and differ in many respects from those required for the fourth and fifth Series, on account of the many faint stars that had to be determined with regard to position and magnitude.

The field chosen for these three Series is one degree square, in whose center is the variable. In this square all the BD stars

* This letter by Father Hagen is in answer to one sent to him requesting information concerning his new Atlas of Variable Stars. The value of the work is evident, and its appearance should give new impetus to the study of variables. It is perhaps not out of place to add that the systematic observation of variable stars is one of the most profitable lines of work into which the amateur can enter. It is a field in which any member of the Astronomical Society of the Pacific can do work, the results of which will be of real benefit to the Science of Astronomy. Editor.

were plotted, and then identified in the sky by means of a five-inch equatorial. Not only were the errors noted, but all the stars of a chart were connected with each other by sequences of brightness, according to ARGELANDER'S method, beginning with the brightest star. This operation was repeated after an interval of many months, generally a year.

After the first three Series were finished in this way, the charts were taken to the 12-inch equatorial for the insertion of the fainter stars. For these fainter stars a smaller square was marked around the variable, viz. half a degree square, covering only one-fourth of the area of the whole chart. The positions of all the stars within this smaller square, visible in our 12-inch refractor, and of all the BD stars of the whole chart, were then determined by means of a semi-circular glass scale, measuring 30′, and divided into ten parts. Thus 3′ could be read directly, and 0′.3 by estimation. The lines were cut in the glass by means of a dividing engine and then painted black by hand rather coarsely, to make them visible in the light of the stars without field illumination. Hence the glass scale was similar to the one used for the BD, but the method of observation was different. The declinations were determined separately from the Right Ascensions while the telescope was following the stars by means of the driving clock. For the R. A. the telescope remained clamped, but the clock was stopped, and the approach of the stars to the vertical diameter of the glass scale was recorded on the chronograph. This record was made three times, not so much to reach greater accuracy as to make sure that the combinations of the Decl. and R. A. were placed beyond doubt. Since the glass scale covers only one-half of a chart, the northern and southern parts of the charts had to be observed separately. In the catalogue the Decl. and R. A. are given differentially from the Variable as zero point. The inclination of the glass reticle to the hour circle was determined from several stars whose position was known either from catalogues or from kind communications of astronomers now engaged in making the southern zones of the A. G., or finally from observations with our own ERTEL transit instrument. All these observations and computations for correcting the inclination of the reticle were carried out by Rev. Father J. T. HEDRICK, S. J.

The chronograph sheet was read off and the new stars plotted on the chart, in different ink, on the morning after the observa-

tion, in order to compare the chart with the sky, and to estimate the brightness of the stars on the first succeeding clear night. All the stars, including the BD stars, were then connected by sequences of brightness, from the brightest to the faintest, and these estimates were repeated about a month later. Hence, all the fainter stars were estimated in brightness twice, besides occasional revisions, and the BD stars four times. Each chart was therefore compared with the sky at least five times.

For the construction of charts it was necessary to transform the sequences of steps into a series of magnitude. For this purpose the steps observed in the 5-inch telescope had to be reduced to those observed in the 12-inch refractor, by a multiplying factor, which changed from one chart to another, and then they were combined into a mean value. The value of one step, expressed in magnitude, had to be found so as to make the computed magnitudes agree as nearly as possible with any of the adopted scales (in this case the BD), at least between the limits 7^m and 10^m. How the step value was computed, and from what starting point it was applied, is of little importance. The test of the method will be the agreement between the two series of magnitudes. This same step value was then applied to the sequences of the fainter stars, without regard to the different limits of magnitude which would thus be reached on different charts. The lowest limit is about $13^m.5$, which is in good accord with the limit expected from a comparison of our charts with those of CHARCORNAC, PETERS, and PALISA. That this lowest limit was not reached on all charts is partly owing to the well-known fact that estimates of steps do not run uniformly from the brighter to the fainter stars, and hence require a variable step value for their reduction to a uniform photometric scale, and partly also owing to the fact that telescopes have no fixed limit of visibility for all parts of the sky and all times of the year. Hence, the magnitudes assigned to the fainter stars of our charts are not to be considered as an extension of the BD scale below the 10th magnitude, but only as serving the immediate purpose of engraving the charts. New magnitudes can be deduced from the steps as soon as a photometric scale is established for stars below the 10th magnitude. All the computations of the magnitudes were made by Mr. M. ESCH, S. J., assistant of this observatory. It may be well to state that the observations at the telescope of positions and brightness were all made by myself.

III. The *charts* of the first three Series measure, as has been said before, one degree in each direction, but the field that contains the faint stars below the 10th magnitude measures only one-half degree in each co-ordinate. The variable star is placed in the middle of the chart, and designated by a circle and a dot in the center, which correspond respectively to its maximum and minimum brightness. The identification of the variable was considered the most important point of the Atlas, and no chart is sent to the engraver before the variation of the star in the center has been established by actual observations. There is good ground for the hope that all errors of this kind have been avoided. The projection of the net is not optical, but artificial, the meridian lines being all parallel and the horizontal lines at equal distances from each other. The color of the net is red, and no letters are printed on the charts. Thus, in red light, which is found very agreeable to the eye when frequent changes from light to darkness are to be made, nothing appears on the chart except the black disks of the stars. This gives them the nearest resemblance to the sky, and facilitates recognizing the configuration.

The inscription of each chart is supposed to furnish everything necessary for the night work, while the catalogue gives other data useful for the computations.

The *Atlas* is published in Berlin, by Mr. FELIX L. DAMES (Voss Strasse, 32). It will be agreeable to your readers to learn that Miss CATHERINE WOLFE BRUCE, so well known for her many contributions to astronomical science, has placed in the hands of Professor EDWARD C. PICKERING a security of nearly two thousand dollars, which, while not covering the expense of engraving and printing of the whole Atlas, has encouraged the publisher to run the risk of this publication.

J. G. HAGEN, S. J.

GEORGETOWN COLLEGE OBSERVATORY, March 19, 1898.

OBSERVATIONS OF *o Ceti* (*Mira*). 1897–98.

BY ROSE O'HALLORAN.

The variable star *o Ceti* attained a greater magnitude last November than during any of the recent years since the maxima commenced to occur in months when the constellation was not obscured by sunlight. Observations were taken of its rela-

tive brightness on eighty-six nights between September 29, 1897, and February 28, 1898; but to avoid repetition, only nights of marked change are mentioned.

September 29. Equal to adjacent star of eighth magnitude.

October 17. Equal to 66 *Ceti.*

October 23. Nearly equal to ξ *Piscium.*

October 26. Brighter than ξ *Piscium.*

November 3. Brighter than δ *Ceti.*

November 10. Moonlight. For the first time since the maxima have occurred out of sunlight the variable is as bright as γ *Ceti.*

November 21. One-fourth of a magnitude brighter than γ when near meridian on a dark sky.

December 1. One-fourth brighter than γ. Moonlight. Clouds.

December 12. Equal to γ.

December 14. Not fully as bright as γ in a clear dark sky.

December 16. About one-fourth dimmer than γ.

December 21. Midway between γ and δ.

December 31. Equal to δ.

January 3. Not fully as bright as δ.

January 7. Even in moonlight not as bright as δ, which being a white star, pales in moonlight.

January 9. Same as ξ *Piscium.*

January 13. About one-third magnitude fainter than ξ *Piscium.*

January 19. Brighter than 66 and 70 *Ceti*, and equal to 75 *Ceti.*

January 24. Less than 75 in luster.

January 28. Equal to 70 *Ceti.*

February 4. In a hazy atmosphere seems brighter than 70.

February 12. The same as 71 *Ceti.*

February 19. Not as bright as 71.

February 28. Half a magnitude fainter than 71 *Ceti.* *Mira* was less than 7 magnitude on this date, when observations were discontinued.

San Francisco, May, 1898.

HONOR CONFERRED ON PROFESSOR SCHAEBERLE.

On commencement day, May 18, 1898, the University of California conferred the honorary degree of LL. D. upon Professor J. M. Schaeberle.

THE RED STARS *V HYDRÆ* AND 277 OF BIRMINGHAM'S CATALOGUE.

BY ROSE O'HALLORAN.

Two crimson stars, now visible in the evening sky, are especially worthy of the notice of telescopic observers. Unlike hundreds of stars classed as red, which, in a steady atmosphere, have merely a pinkish-yellow hue, these orbs preserve their claim to redness under all conditions of visibility. The brighter of the two, *V Hydræ*, in R. A. $10^h\ 46^m\ 17^s$ Decl. $+20°\ 40'$, may be found (even with an opera-glass) west of α and β *Crateris*, with which it forms a triangle. Since the beginning of April, it has maintained a deep crimson color, though described as pale crimson, copper-red, and intensely red, by reliable observers in the past. At present it is of the seventh magnitude, and it is known to vary from the sixth to the ninth, though the period seems to be uncertain or irregular, being about 575 days, according to GOULD, but 653 days if the recent data of the *Companion to the Observatory* be correct. The last maximum having been predicted for October 25, 1896, in this ephemeris, the next may occur in the middle of August, when *V Hydræ* sets in sunlight, but its altitude will be sufficiently high for observation for some weeks yet. Spectroscopists describe the spectrum of this star as being strongly lined in the red and green, and class it as of the fourth type.

Another orb, unusually free from yellow light, is numbered 277, in BIRMINGHAM'S catalogue of red stars. Being in R. A. $12^h\ 19^m\ 37^s$ Decl. $+\ 1°\ 22'$ it may be found about $2°$ northeast of η *Virginis*. Fitly classed as crimson, it is recognized as a variable, with a range of from six and a half to eight and a half magnitude, though its period seems to be unknown. In numerous observations during the spring months of the last five years, I have failed to detect any variation greater than from about seven and a half to eight magnitude. It is considered that its spectrum is probably of the fourth type, and as it terminates in the green, this interesting orb may be surrounded by dense vapors that obstruct all radiation of violet light.

SAN FRANCISCO, May 20, 1898.

A NEW ASTRONOMY FOR BEGINNERS. BY DAVID P. TODD, M. A., PH. D., PROFESSOR OF ASTRONOMY AND DIRECTOR OF THE OBSERVATORY, AMHERST COLLEGE. AMERICAN BOOK CO., NEW YORK. 12MO. 480 PP. $1.30.

As indicated in the title, this book is intended for those having no previous acquaintance with astronomy. It is written in an easy, descriptive style, and without presupposing mathematical knowledge beyond the most elementary notions of geometry. By far the greater part of the work is devoted to a description of the fundamental principles of the science; next in order comes the exposition of well ascertained facts, while matters that are as yet mere theories rightly receive but little attention. The portions of the book devoted to the methods and results of astrophysical research are very limited, amounting to less than five per cent of the whole, or much less than would be expected in view of the prominence which has attached to this department of the subject.

The book contains nearly 350 illustrations, most of them very good. They may be roughly grouped as follows: Six colored plates, some sixty astronomical drawings and celestial photographs, some twenty illustrations of instruments and observatories, and many diagrams. These diagrams constitute a characteristic feature of the book. In most cases, words, phrases or sentences are printed along the lines forming them, so as to make their meaning clear without further explanation, though such explanation is also given in the text. Another characteristic feature is the detailed directions for the construction and use of simple apparatus to enable the student to derive from his own observations, in a rough way, to be sure, but correct in principle, approximate values of some of the more easily obtainable astronomical constants.

While the book, as a whole, is a good one, and contains a large amount of well-selected and accurate information concerning astronomical matters, there are, as may be expected in first editions, some blemishes that appear in the course of a critical examination. One of these is an occasional incompleteness of description, marring somewhat the effectiveness of the exposition. This, in general, is not serious, and in part seems to result from the plan of the work, in that elementary explanations are

often first given, to be followed later by more complete ones. Such, however, is not always the case. For example, the account of TALCOTT's method for finding the latitude (p. 85) carefully omits the fundamental principle of the method. We also notice the occasional inclusion of matter wholly irrelevant to the subject of the paragraph in which it is given. This, of course, is of little consequence, and merely indicates imperfection in the order of arrangement. Some of the statements made in relation to the surfaces of the planets, particularly some of those giving interpretations in explanation of the phenomena observed on *Mars*, are not likely to pass unchallenged. The last sentence on page 121, viz., "About the 20th March, at mean noon, when the fictitious sun is crossing the equator, etc.," reads strangely, in view of the fact that this "fictitious sun" (p. 111) travels in the equator. Chapter II, which is probably the weakest in the book, contains some loose description, some poor diagrams and some erroneous definitions. The diagrams on pp. 35 and 37 bid defiance to the laws of projective geometry, and it is difficult to imagine how they can be otherwise than confusing to the student. On page 37, the ecliptic is defined in such a way as to be a fixed circle in reference to the horizon, and on the next page the equinoxes in such a way as to be fixed points in the meridian. The logical consequence of these definitions would be that the solstices are fixed points in the horizon, coincident with the east and west points. The definitions referred to are as follows: "Imagine the equator system pivoted at the two opposite points where equator and meridian cross. Then carry the north pole towards the west 23½°. The equator will then have assumed a position inclined by an angle of 23½° to its former position. It will, in short, have become the ecliptic. . . . Upper of the two pivotal points upon which the equator turned about meridian is called the *Vernal Equinox*, or First of Aries; its opposite point, 180° away, the *Autumnal Equinox*." These definitions, as they stand, are wholly inadmissible. They lack completeness and accuracy of statement, and do much to accentuate the looseness of expression prevalent in the chapter containing them.

W. J. HUSSEY.

May 30, 1898.

PLANETARY PHENOMENA FOR JULY AND AUGUS 1898.

By Professor Malcolm McNeill.

July.

Eclipses. There will be two eclipses during the month, b neither of them will be visible in the United States. The first, c July 3d, is a partial eclipse of the Moon, not quite total. It w be visible over nearly all of the eastern hemisphere. The secon is an annular eclipse of the Sun on July 18th. The path of th annulus is entirely in the South Pacific ocean. It will be see as a partial eclipse in the southern part of South America.

The Earth is in aphelion on the morning of July 2d.

Mercury is an evening star, having passed superior conjunction on the morning of June 30th, and during the latter half o the month it sets a little more than an hour after sunset; so i may be seen under good conditions of weather. It makes a very close approach to the first magnitude star α *Leonis* (*Regulus*) on the morning of July 27th during daylight in the United States, but the planet and star will not be far apart on the evenings of July 26th and 27th.

Venus is an evening star setting about two hours after the Sun. It moves 33° east and 13° south during the month through the constellation *Leo*, passing 1½° north of *Regulus* on July 13th. Its apparent distance east of the Sun increases 3°, but on account of its great southern motion the interval between sunset and the setting of the planet diminishes about a quarter of an hour.

Mars rises earlier than before, only a little after midnight toward the close of the month. It moves 21° east and 5° north in the constellation *Taurus*, and on July 31st is about 5° north of the first magnitude red star *Aldebaran*, α *Tauri*. It distance from the Earth on July 15th is about 160,000,000 miles, and it will be nearly twice as bright as it was during January.

Jupiter is still conspicuous in the southwestern sky in the evening. It moves 3° east and south in the western part of the constellation *Virgo*.

Saturn is in good position to be seen until after midnight. It moves about 1° westward, and is about 7° north and a little west of the first magnitude red star *Antares*, α *Scorpii*. The outer

minor axis of the rings is just about the same as the diameter of the planet.

Uranus is in the same neighborhood as *Saturn*, about half an hour ahead. It moves about 1° westward in the constellation *Scorpio*. It may be found by its proximity to the third magnitude star *β Scorpii*. On July 1st it is about 2° west of the star.

Neptune is a morning star in the eastern part of *Taurus*.

AUGUST.

Mercury is an evening star and comes to greatest east elongation on August 9th. It remains far enough from the Sun to be be seen under good conditions of weather through the first half of the month, but during the latter half it rapidly approaches the Sun, and it will reach inferior conjunction on September 5th.

Venus is still an evening star. The interval between its setting and sunset diminishes about 10^m during the month, although it does not reach its greatest eastern distance from the Sun until nearly the close of September. It moves 30° east and 15° south during the month from the constellation *Leo* into *Virgo*, and on August 30th passes about 1° north of the first magnitude star *Spica*, *α Virginis*.

Mars rises before midnight at the end of August. It moves about 21° eastward during the month in the constellation *Taurus*. Its distance from the Earth diminishes 20,000,000 miles during the month and at the end is less than 140,000,000. Its brightness will perceptibly increase.

Jupiter is rapidly approaching conjunction with the Sun, and at the end of the month can be seen for only a short time after sunset. It moves about 5° east and 2° south in the western part of *Virgo*.

Saturn is still in fair position for observation, not setting until late in the evening. It is in quadrature with the Sun on August 29th. It is nearly stationary in the constellation *Scorpi* but after August 9th moves a fraction of a degree eastward.

Uranus is also nearly stationary in the same constellation, about 2° west of the third magnitude star *β Scorpii*.

Neptune rises before midnight at the end of the month.

Phases of the Moon, P. S. T.

			H. M.
Full Moon,	July 3,	1 12 P. M.
Last Quarter,	July 10,	8 43 A. M.
New Moon,	July 18,	11 47 A. M.
First Quarter,	July 26,	5 40 A. M.
Full Moon,	Aug. 1,	8 29 P. M.
Last Quarter,	Aug. 8,	10 13 P. M.
New Moon,	Aug. 17,	2 34 A. M.
First Quarter,	Aug. 24,	12 32 P. M.
Full Moon,	Aug. 31,	4 51 A. M.

The Sun.

1898.	R. A. H. M.	Declination. ° ′	Rises. H. M.	Transits. H. M.	Sets. H. M.
July 1.	6 42	+ 23 6	4 41 A. M.	12 4 P.M.	7 27 P.M.
11.	7 23	+ 22 5	4 46	12 5	7 24
21.	8 3	+ 20 26	4 53	12 6	7 19
Aug. 1.	8 47	+ 17 58	5 3	12 6	7 9
11.	9 25	+ 15 12	5 13	12 5	6 57
21.	10 2	+ 12 2	5 22	12 3	6 44
31.	10 39	+ 8 33	5 31	12 0 M.	6 29

Mercury.

July 1.	6 49	+ 24 24	4 40 A.M.	12 10 P.M.	7 40 P.M.
11.	8 17	+ 21 35	5 43	1 0	8 17
21.	9 29	+ 16 8	6 36	1 32	8 28
Aug. 1.	10 28	+ 9 16	7 16	1 48	8 20
11.	11 5	+ 3 35	7 33	1 45	7 57
21.	11 22	− 0 3	7 22	1 22	7 22
31.	11 9	+ 0 41	6 28	12 30	6 32

Venus.

July 1.	9 6	+ 18 30	7 23 A.M.	2 28 P.M.	9 33 P.M.
11.	9 53	+ 14 38	7 45	2 35	9 25
21.	10 37	+ 10 10	8 5	2 40	9 15
Aug. 1.	11 23	+ 4 49	8 27	2 43	8 59
11.	12 4	− 0 16	8 45	2 44	8 43
21.	12 44	− 5 21	9 3	2 45	8 27
31.	13 24	− 10 16	9 20	2 45	8 10

Mars.

July 1.	3 2	+ 16 16	1 26 A.M.	8 23 A.M.	3 20 P.M.
11.	3 30	+ 18 14	1 9	8 13	3 17
21.	3 59	+ 19 54	12 51	8 2	3 13
Aug. 1.	4 30	+ 21 22	12 34	7 50	3 6
11.	4 58	+ 22 22	12 18	7 39	3 0
21.	5 26	+ 23 3	12 4	7 27	2 50
31.	5 54	+ 23 26	11 50 P.M.	7 15	2 40

JUPITER.

July	1.	12 10	+ 0 21	11 30 A.M.	5 31 P.M.	11 32 P.M.
Aug.	1.	12 24	− 1 20	9 47	3 43	9 39
	31.	12 44	− 3 31	8 17	2 5	7 53

SATURN.

July	1.	16 21	− 19 38	4 50 P.M.	9 41 P.M.	2 32 A.M.
Aug.	1.	16 16	− 19 33	2 44	7 35	12 26
	31.	16 18	− 19 43	12 47	5 38	10 29 P.M.

URANUS.

July	1.	15 52	− 20 0	4 23 P.M.	9 12 P.M.	2 1 A.M.
Aug.	1.	15 49	− 19 55	2 19	7 8	11 57 P.M.
	31.	15 50	− 19 58	12 22	5 11	10 0

NEPTUNE

July	1.	5 29	+ 21 59	3 32 A.M.	10 51 A.M.	6 10 P.M.
Aug.	1.	5 34	+ 22 1	1 35	8 54	4 13
	31.	5 37	+ 22 2	11 39 P.M.	6 58	2 17

ECLIPSES OF *JUPITER'S* SATELLITES, P. S. T.

(Off right-hand limb, as seen in an inverting telescope.)

			H. M.				H. M.
I, R,	July	2.	7 47 P. M.	II, R,	Aug.	7.	8 6 P. M.
III, D,		5.	9 40 P. M.	III, D,		10.	6 38 P. M.
II, R,		6.	8 27 P. M.	III, R,		10.	7 51 P. M.
I, R,		9.	9 42 P. M.	I, R,		17.	8 14 P. M.
I, R,		18.	6 6 P. M.	I, R,		26.	4 37 P. M.
I, R,		25.	8 1 P. M.				
II, R,		31.	5 31 P. M.				

(TWENTY-NINTH) AWARD OF THE DONOHOE COMET-MEDAL.

The Comet-Medal of the Astronomical Society of the Pacific has been awarded to C. D. PERRINE, Assistant Astronomer in the Lick Observatory, for his discovery of an unexpected comet on March 20, 1898.

The Committee on the Comet-Medal,

J. M. SCHAEBERLE,
WM. M. PIERSON,
CHAS. BURCKHALTER.

May 20, 1898.

NOTICES FROM THE LICK OBSERVATORY.*

PREPARED BY MEMBERS OF THE STAFF.

PHOTOGRAPH OF THE TOTAL ECLIPSE OF THE SUN, JANUARY 22, 1898.

[See Frontispiece.]

The original negative from which the eclipse plate, shown in our frontispiece, was made, was taken by Professor CAMPBELL with the Floyd telescope, exposure time five seconds.

Those who are familiar with the difficulty of making even satisfactory contact positives from eclipse negatives, need not be told that a large part of the detail shown by the original is necessarily lost in the reproduction. A notion of the general form of the corona only can be gained from the print; the details must be studied on the original negatives.

CHANGES IN THE STAFF OF THE LICK OBSERVATORY.

Professor JAMES E. KEELER arrived at Mt. Hamilton and assumed his duties as Director of the Lick Observatory on June 1st. Professor CAMPBELL returned to the Observatory from his expedition to India on the same day.

A note concerning Professor SCHAEBERLE'S resignation will be found on another page.

ELECTRIC ILLUMINATION OF THE MICROMETERS AT THE LICK OBSERVATORY.

For nearly two years and a half, electric illumination has been used for the micrometers of both the 12- and 36-inch telescopes, and it has proved so satisfactory that oil illumination is no longer in use except on rare occasions and then only in case of emergency. The current is supplied by a storage battery, five cells of which are ordinarily used on a lamp at a time, giving about ten volts, one-half ampere and one-half candle power. The battery is

* Lick Astronomical Department of the University of California.

charged from time to time, as may be necessary, by means of a dynamo.

In each case the electric lamp is fitted to the end of a small wooden cylinder of the same size as the oil lamp previously used. This cylinder takes the place of the oil lamp in the apparatus attached to the micrometer, no change in this being made. Wires run from the lamp through the cylinder to a switch within easy reach of the observer at the eye-end of the telescope. The wires from the battery are brought up to the pier, where a cable is attached of sufficient length to reach any part of the dome. A plug at the end of the cable completes the circuit at the switch.

This arrangement is very satisfactory, and it has decided advantages over oil illumination. It is perfectly under control, any degree of illumination of the wires being easily obtained. It may be instantly extinguished by turning the switch or by withdrawing the plug, and as readily turned on. It is not affected by wind and there is no dripping oil. It may be completely covered up, preventing the escape of extraneous light, which is especially desirable in observing exceedingly faint objects. And it takes but a moment to change to the oil lamp in the case of emergency.

W. J. HUSSEY.

THE LOWELL OBSERVATORY CATALOGUE OF DOUBLE STARS.

A most important contribution to double-star astronomy is Dr. T. J. J. SEE's catalogue of "Discoveries and Measures of Double and Multiple Stars in the Southern Heavens," recently published in the *Astronomical Journal*. The catalogue contains the positions for 1900.0, and measures of the position-angle and distance of 500 new stars between the limits 20° and 65° South Declination, which were found by Dr. SEE and Mr. COGSHALL with the 24-inch telescope of the Lowell Observatory during the sixteen months ending December 31, 1897. The components of 122 of the stars are separated by less than 1″, and in many of the wider pairs one component is very faint. With respect to the proportion of close and difficult stars contained, the list therefore takes a high rank. In the course of the work, 500 stars previously known were measured also,* and, Dr. SEE states, more than 100,000 stars were carefully examined.

It is to be regretted that the magnitude of the undertaking

* Measures to be published later in *A. N.*

prevented the carrying out of the original plan of measuring each star on three different nights. Nearly three-fifths of the number were passed with two observations made on one night only and by one observer only. One fears that the positions resulting from such measures, though "made in a manner as independent as possible," will not be sufficiently reliable to make it certain that differences between these and future measures are due to motion in the stars. For, as noted above, many of the stars are difficult, and the catalogue contains a number of instances of discordances in the measure of a star by the same observer on different nights, amounting in some cases to from 1″ to 3″ in a mean distance of 8″ or less, and occasionally to 10°, and even more, in position angle. We must also acknowledge that we cannot understand why some discordant measures are rejected (e. g. λ_1 42, λ_1 112), while others, equally discordant (e. g. λ_1 76, λ_1 170) are given full weight.

It is to be hoped that Dr. SEE may soon find time—even at the cost of delaying the completion of his survey of the southern heavens—to recur to the more promising of those stars in the present catalogue which were measured on one night only, and, by additional measures, place the present position of the components beyond doubt; for it is highly probable that a number of these stars will show rapid motion. R. G. AITKEN.

CHANGES IN THE AMERICAN EPHEMERIS.

In the preface to the American Ephemeris for 1900, just received, Professor HARKNESS states that certain changes of importance have been introduced in the volume. "First, the constant of precession for the epoch 1900.0 has been changed from 50″.2638 to 50″.2482; the constant of nutation for the same epoch has been changed from 9″.2231 to 9″.21; the constant of aberration has been changed from 20″.4451 to 20″.47; and the constant of solar parallax from 8″.848 to 8″.80. Second, Professor NEWCOMB'S tables of the Sun, *Mercury* and *Venus*, and Dr. HILL'S final printed (as distinguished from his provisional manuscript) tables of *Saturn* have been substituted for the tables which were formerly used. Third, the 175 additional fixed stars, whose apparent Right Ascensions only were heretofore given, have been transferred to the regular list, which now contains their complete apparent places throughout the year."

The volume, it seems, was prepared entirely under Professor NEWCOMB'S supervision, before his retirement in 1897.

The changes in the astronomical constants above noted are made in conformity with the decisions of the *Paris Conference on Fundamental Stars*, held in May, 1896. They have also been introduced in the English *Nautical Almanac* for 1901, recently issued, and will be introduced in the Berliner *Astronomisches Jahrbuch* and the *Connaissance des Temps* for the same year.

Considerable opposition to these changes at this time has developed among astronomers; and those who are interested may find a vigorous discussion of the subject in recent numbers of the *Astronomical Journal*. R. G. A.

Solar Observations in 1897.

In the *Astrophysical Journal* for March 1898, Professor P. Tacchini gives a résumé of the solar observations made at the Royal Observatory of the Roman College during the second half of 1897. From his tables it is seen that the spots have continued to decrease, particularly in area, while the prominences have remained practically stationary in activity. The prominences have continued to show themselves in nearly all zones — with a maximum of frequency between the equator and — 20°. Two secondary maxima, however, occurred in the zones ± 40° to ± 60°. The spots were confined to regions within 20° of the equator. One eruption was observed on November 23d. A very bright jet suddenly formed on the west limb at latitude + 8°.2 and rose to the height of 168″ (about 15,000 miles), disappearing in twenty minutes. R. G. A.

New Elements of Comet *b* 1898.

I have derived the following elements, using my observations of March 19th, 22d, and 26th.

$$T = 1898 \text{ March } 16^{d}.79123$$

$$\left.\begin{array}{ll} \omega = & 46^\circ\ 57'\ 11''.6 \\ \Omega = & 262\ \ 18\ \ 53\ .1 \\ i = & 72\ \ 21\ \ 14\ .4 \end{array}\right\} \begin{array}{c}\text{Ecliptic and} \\ \text{Mean Equinox of 1898.0.}\end{array}$$

$$\log q = 0.040024.$$

Residuals for the middle place, observed — computed

$$\begin{array}{ll} \Delta\lambda' \cos\beta' & +0''.3 \\ \Delta\beta' & -0\ .3 \end{array}$$

C. D. Perrine.

Mt. Hamilton, April 5, 1898.

ELLIPTIC ELEMENTS OF COMET *b*, 1898, AND A CERTAIN SIMILARITY TO THE COMETS OF 1684, AND 1785 I.

Using the following observations of this comet:—

1898.	Mt. Hamilton M. T.	App. α	App. δ
March 19,	$16^h\ 47^m\ 21^s$	$21^h\ 18^m\ 36^s.89$	$+16°\ 43'\ 23''.3$
April 8,	16 19 7	22 41 0.88	+36 20 50 .5
April 28,	15 26 54	0 23 20.68	+49 41 32 .4

I obtained the following system of parabolic elements:—

$$T = 1898 \text{ March } 17.35984 \text{ Gr. m. t.}$$

$$\left.\begin{array}{l} \omega = \ \ 47^\circ\ 36'\ \ 8''.0 \\ \Omega = 262\ \ 32\ \ 26\ .3 \\ i = \ \ 72\ \ 26\ \ 50\ .4 \end{array}\right\} \begin{array}{c}\text{Ecliptic and} \\ \text{Mean Equinox 1898.0}\end{array}$$

$$\log q = 0.040820$$

The residuals from these elements for the middle place being—

Observed — Computed, $\Delta\ \lambda' \cos \beta'$ $-14''.7$

$\Delta\ \beta'$ $+22\ .4$

From the same observations I then obtained the following system of elliptic elements:—

Epoch 1898, March, 20.0 Gr. m. t.

$$M = \ \ 0^\circ\ \ 0'\ \ 34''.1$$

$$\left.\begin{array}{l} \omega = \ \ 47\ \ 14\ \ 48\ .8 \\ \Omega = 262\ \ 24\ \ 42\ .9 \\ i = \ \ 72\ \ 32\ \ 55\ .8 \end{array}\right\} 1898.0$$

$\log q = 0.039179$

" $a = 1.656386$

" $e = 9.989386$

" $\mu = 1.065428$

$\mu = 11''.62595$

$\phi\ 77^\circ\ 23'\ 3''.5$

Period, 305.208 years.

The residuals for the three places used are:—

O—C.

α	δ
$-1''.2$	$+1''.1$
$-0\ .3$	$-1\ .2$
$+0\ .5$	$+1\ .1$

The brightness of the comet remained almost unchanged for several weeks. The comet has been losing its light more rapidly the past ten days. It still retains its stellar nucleus; but this, too, is fading slowly, and is not brighter now than 10 magnitude.

Since ascertaining that this comet is periodic I have been led to notice more particularly a similarity which exists between its orbit and those of 1684 and 1785 I. Below are the approximate elements of the three comets for comparison:—

	ω	Ω	i	q
1684	330°.3	268°.2	65°.4	0.958
1785 I	205 .7	264 .2	70 .2	1.143
1898 *b*	47 .6	262 .5	72 .4	1.094

The agreement of the positions and dimensions (Ω, i, and q) of the three orbits is sufficiently close to warrant the belief that the three comets belong at least to the same family. The differences in ω are very large, too large to believe at first sight that the orbits all belong to the same comet—unless the discrepancies can be satisfactorily accounted for. It is to be noticed, however, that the variations in ω are in the same direction. The intervals of 101 and 113 years do not agree well with the period found for the present comet, on an assumption that all three are appearances of the same object. The period of 305 years for the present comet must be considered uncertain to a large degree, however. All things considered, it looks more as if all three comets were members of one family than that they were appearances of the same body.

The comet of 1684 was discovered by BIANCHINI at Rome, and was visible to the naked eye. It was visible only a short time, the observations extending over the period July 1–17, only.

The comet of 1785 I was discovered by MESSIER at Paris. While it does not appear to have been so bright as the one o 1684, it was observed for some five weeks. C. D. PERRINE.

MT. HAMILTON, Cal., May 9, 1898.

COMETARY DISCOVERIES.

The total number of comets observed sufficiently well during the last thirty years (1868–1897) for their orbits to be calculated amounts to one hundred and thirty-five, but of these thirty-seven were returns of periodic comets which had been previously seen.

The average rate of apparition of new comets has, therefore, been 3.27 annually, and of new and periodic comets, 4.5 annually. In 1873, 1881, 1892, and 1896, seven comets were discovered; in 1872 not one was observed; and in 1875 the only two comets which appeared were known ones. The best months for the discovery of these objects appear to be July and August.

Of three hundred and twenty-eight comets discovered between the years 1782 and 1897, inclusive, the following are the numbers in the various months:—

January,	22	July,	37
February,	21	August,	43
March,	24	September,	25
April,	27	October,	26
May,	20	November,	34
June,	22	December,	27

These figures include every description of those objects. During the sixty years from 1782 to 1841 there were eighty-seven comets, averaging 1.45 per year; but during the fifty-six years from 1842 to 1897 there were two hundred and forty-one comets, averaging 4.30 per year. W. F. DENNING.

Knowledge, April, 1898.

THE VARIABLE STAR *Z CENTAURI* AND THE NEBULA N. G. C. 5253.

In December, 1895, the Harvard College Observatory announced that from an examination of the DRAPER Memorial photographs taken at Arequipa, Peru, Mrs. FLEMING had discovered a "new star" in the constellation *Centaurus*. The variable character of this star has since been fully established, and it has received the definitive name *Z Centauri*.

No trace of the star has been found on the fifty-five photographs taken from May, 1889, to June, 1895, but it appears on those of July, 1895, having a brightness of 7.2 magnitude, and on that of December 19, 1895, as 11 magnitude.

In the latter part of December, Professor CAMPBELL estimated its magnitude at 11.2. During the two months following it decreased in brightness very slightly. On June 11, 1896, I found that it had decreased to 14.4 magnitude. Fifteen days later it was 15¼, and on July 9, nearly 16. Since then I have looked for it every month or two when within reach, and on all these occasions have found it either invisible in the large telescope or not brighter than the 16th magnitude. During this time, when visible, the star has been difficult on account of the faint nebula surrounding it. This nebula, when seen under the best conditions, has every appearance of being a part of the nebula N. G. C.

5253. Regarding it so, the latter nebula, as seen in the large telescope, may be described as having somewhat the same form as the Great Nebula in *Andromeda* as seen in a very small telescope. There are, however, these important differences: N. G. C. 5253 has a relatively stronger central condensation, and its ends are not equally bright, the south preceding end being many times brighter than the north following end in which *Z Centauri* is situated. W. J. HUSSEY.

"A REMARKABLE OBJECT IN PERSEUS."

In the *Wolsingham Observatory Circular*, No. 46, Rev. T. E. ESPIN announces the discovery of "A remarkable object, hitherto unrecorded, on January 16, and seen on three other nights." He describes it as elliptical, one degree long, major axis 330°, and rather resembling some obscuring medium than a nebula.

At the first opportunity after the receipt of the notice of this discovery at the Lick Observatory, I obtained photographs of this region with the Crocker Telescope. The exposures were two hours in length, and the nights first-class. My plates show an elliptical area largely devoid of stars in the position given by Mr. ESPIN for his object. This area corresponds exactly to a like one on the DM charts. My plates also show other areas devoid of stars, but none so large or so symmetrical as that referred to, and it is well known that many such areas abound in the Milky Way. E. F. CODDINGTON.

May 20, 1898.

A CORRECTION.

It seems desirable to correct a statement contained in the May issue of *Popular Astronomy*.

My resignation from the Lick Observatory takes effect at the close of the present month, and not one year hence, as stated in the above-mentioned publication.

The Regents of the University of Californina urged me to withdraw my resignation, and offered me a year's leave of absence with full pay, but I could not accept their kind offer, as I feel satisfied that my present course is the proper one for me to take.

In justice to Professor KEELER, I desire to say, that had the Regents elected any other man as director my action would have been exactly the same. J. M. SCHAEBERLE.

LICK OBSERVATORY,
UNIVERSITY OF CALIFORNIA, May 11, 1898.

RECENT CHANGES IN THE DOUBLE STAR OΣ 341.

I have recently examined OΣ 341 on three good nights with the 36-inch telescope without obtaining any indication of its being double. This result was wholly unexpected. All the measures of the star from the first ones in 1846, to the last ones in 1886, are in fairly good agreement in indicating that the components are relatively fixed. Previous observers have generally estimated the magnitudes the same, 7.0 or 7.5, and the average of the distances given by the measures from 1846 to 1886 is between 0″.4 and 0″.5. At this distance, on a good night, the star would be an easy object for the large telescope. The star has closed up since 1886, and this shows that the motion since that time has been rapid. It also proves that the star is a binary, and it is not difficult to imagine such a disposition of the elements of its orbit as will account for the apparent fixity of the components during the period mentioned. For illustration, if we arbitrarily assume the following system of elements:—

$$T = 1898.33$$
$$\Omega = 90^\circ$$
$$\omega = 90^\circ$$
$$i = 90^\circ$$
$$e = 0.75$$
$$a = 0''.75$$
$$\mu = 1^\circ.5$$

Period, 240 years;

and compute the positions for the dates of observation and compare them with the observed places, we shall obtain the residuals given in connection with the observations below. The observations that I have found are as follows:—

Date.	Position angle.	Distance.	No. of nights.	Residuals. O—C		Observer.
1846.09	93°.0	0″.53	3	+ 3°.0	+ 0″.09	OTTO STRUVE
1852.27	95 .5	0 .52	3	+ 5 .5	+ 0 .05	OTTO STRUVE
1866.32	88 .5	0 .6 est.	3, 1	− 1 .5	+ 0 .10	DEMBOWSKI
1871.61	90 .7		3, 0	+ 0 .7		DEMBOWSKI
1878.28	84 .0	0 .38	3	− 6 .0	− 0 .09	SCHIAPARELLI
1883.64	91 .4	0 .40	3	+ 1 .4	− 0 .02	PERROTIN
1884.55	91 .2	0 .45	3	+ 1 .2	+ 0 .04	PERROTIN
1886.39	86 .3	0 .52	7	− 3 .7	+ 0 .21	ENGELMANN
1898.32	Single.		3	0 .0	0 .00	HUSSEY

It may be noted that DEMBOWSKI, SCHIAPARELLI and ENGELMANN observed with small telescopes, of 7½ and 8 inches aperture, and that the star must have been very difficult for them. DEMBOWSKI did not measure the distance, and estimated it on one night only. SCHIAPARELLI'S largest position-angle differs 17°.8 from his smallest, and ENGELMANN'S largest 30°.7 from his smallest. These discordances bear witness to the difficulty of the star for these observers, and may account for the magnitude of some of the residuals given above.

It is evident that no reliable system of elements for this star can now be obtained. The necessary data for the determination of the orbit does not exist. It will be necessary to wait, at least, until the star becomes measurable again. The elements above are given merely to show that the long period of apparent fixity of the components and their present closeness or singleness are not incompatible, but that they find a ready explanation in the binary character of the star. W. J. HUSSEY.

May 24, 1898.

NEW ELEMENTS OF COMET *b* 1898, (PERRINE).

From my observations of March 21st, April 8th, and April 22d, I have computed the following elements of this comet:—

$$T = 1898 \text{ March } 17.37195 \text{ Gr. M. T.}$$

$$\left.\begin{array}{rl} \omega = & 47^\circ\ 37'\ 6''.2 \\ \Omega = & 262\ \ 33\ \ \ 5\ .7 \\ i = & 72\ \ 26\ \ 56\ .1 \end{array}\right\} \text{Ecliptic and Mean Equinox of 1898.0.}$$

$$\log q = 0.040916$$

$$\text{O—C: } \Delta\lambda' \cos\beta' = -4''.2, \quad \Delta\beta' = +12''.4$$

From the same observations I also computed three other systems of elements, using different values of the ratio of the curtate distances. The four systems of elements are nearly the same. The residuals given above cannot be materially improved; their ratio may be changed, but the sum of their squares cannot be sensibly diminished. A careful examination of the data does not reveal any error to which the magnitude of the residuals may be attributed. These circumstances, taken in connection with the fact that the comet has a well-defined nucleus, making accurate observations of it comparatively easy, lead to the conclusion that the true elements of the orbit are not parabolic. W. J. HUSSEY.

April 28, 1898.

A New Large Nebula in *Ursa Major*.

While examining some negatives which I obtained with the Crocker telescope on April 17 and 20, 1898, I discovered a large faint nebula not given in N. G. C., nor in the supplement to N. G. C., nor have I been able to find it in any of the more recent catalogues.

On the night of April 22d, Professor Hussey and I observed it with the 12-inch telescope, and found the position of its brightest condensation to be

$$\alpha = 10^h\ 18^m\ 7^s$$
$$\delta = +69^\circ\ 10'.1$$

referred to the mean equinox of 1860.0.

The telescope shows it to be large, irregular, very faint, and composed of a number of condensations.

On May 19th I obtained an additional photograph of this region with an exposure of four hours. This shows the different condensations to be connected by faint nebulous matter, and the whole to extend over an area fully 4′ in width and 12′ in length.

E. F. Coddington.

May 25, 1898.

The Rumford Medal.

"At the annual meeting of the American Academy of Arts and Sciences held in Boston on May 11th, the report of the Rumford Committee, which was there presented, contained the following important statement and recommendation:—

The committee has also considered at length the question of an award of the Rumford medal. The claims of various investigators and inventors have been considered with great care, and more than one among them appeared to be deserving of such recognition. After prolonged consideration, the Rumford Committee has voted at two separate sessions (in accordance with long-established custom) to recommend to the Academy an award of the medal to Professor James E. Keeler, now Director of the Lick Observatory, for his application of the spectroscope to astronomical problems, and especially for his investigations of the proper motions of the nebulæ, and the physical constitution of the rings of the planet *Saturn*, by the use of that instrument.

The report of the committee was presented by the chairman, Professor Cross, who explained at some length the particular nature and merit of the investigations of Professor Keeler for

which the award of the Rumford premium was proposed, after which the Academy voted unanimously to adopt the recommendation of the committee.

The last previous award of the medal was to Mr. T. A. EDISON, in 1895. Among others who have recently received it are Professors PICKERING, MICHELSON, LANGLEY, and ROWLAND."—*Science*, May 27, 1898.

STELLAR PARALLAX.

From Herr BRUNO PETER's results, published in *A. N.* 3483, of a series of observations made with the Leipzig heliometer during the years 1887–92, we have taken the following list of values for parallax and proper motion:—

Star.	P. M.	Parallax.
η Cassiopeiæ	1".20	+0".18
μ Cassiopeiæ	3 .74	+0 .13
Lal. 15290	1 .97	+0 .02
Lal. 18115 prec.		+0 .18
Lal. 18115 fol.		+0 .18
Lal. 18115 mean	1 .69	+0 .18
θ Ursæ majoris	1 .11	+0 .09
A. Œ. 10603	1 .45	+0 .17
β Comæ	1 .20	+0 .11
31 *Aquilæ*	0 .96	+0 .06
Bradley 3077	2 .08	+0 .13

R. G. A.

ERRATUM.

In No. 61 of these *Publications*, p. 78, line 1, word 2, for date read data.

MINUTES OF THE MEETING OF THE BOARD OF DIRECTORS, HELD AT THE LICK OBSERVATORY, JUNE 11, 1898.

President AITKEN presided. A quorum was present. The minutes of the last meeting were approved. The following members were duly elected:—

LIST OF MEMBERS ELECTED JUNE 11, 1898.

Mr. FRED. R. FRENCH	Room 3, City Hall, Brockton, Mass.
Mr. C. J. GOODRICH	Robinson, Brown Co., Kansas.

It was, upon motion

Resolved, That the Publication Committee be empowered to furnish reprints of articles free of cost to persons contributing by request.

The name of Professor JAMES E. KEELER, Director of the Lick Observatory, was added to the Comet-Medal Committee, to date from June 1, 1898, Professor J. M. SCHAEBERLE retiring.

The Committee on the Comet-Medal is now composed of Messrs. JAMES E. KEELER (*ex-officio*), WM. M. PIERSON, CHAS. BURCKHALTER.

Adjourned.

MINUTES OF THE MEETING OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC, HELD AT THE LICK OBSERVATORY, JUNE 11, 1898.

President AITKEN presided. The minutes of the last meeting were approved. The Secretary read the names of the new members elected at the Directors' meeting.

The following papers were presented:—

1. A Variable Star Atlas, by Father J. G. HAGAN.
2. On the Causes of the Sun's Equatorial Acceleration and the Sun Spot Period, by Mr. E. J. WILCZYNSKI.
3. Review on Professor TODD'S "New Astronomy," by Professor W. J. HUSSEY.
4. Observations of *Mira Ceti*, by Miss ROSE O'HALLORAN.
5. The Red Stars, *V Hydrae* and 277 of Birmingham's Catalogue, by Miss ROSE O'HALLORAN.
6. Planetary Phenomena for July and August, 1898, by Professor MALCOLM MCNEILL.
7. Professor JAMES E. KEELER exhibited photographs of the Spectra of Stars obtained at the Allegheny Observatory.

Adjourned.

OFFICERS OF THE SOCIETY.

Mr. R. G. Aitken . . . . *Pr*

Mr. C. B. Hill . . . . *First Vice-Pr*

Miss R. O'Halloran . . . . *Second Vice-Pr*

Mr. F. H. Seares . . . . *Third Vice-Pr*

Mr. C. D. Perrine }
Mr. F. R. Ziel } . . . . *Secr*

Mr. F. R. Ziel . . . . *Tre*

Board of Directors—Messrs. Aitken, Hill, Keeler, Molera, Miss O'Halloran, I
Perrine, Pierson, Seares, St. John, von Geldern, Ziel.

Finance Committee—Messrs. Pierson, von Geldern, Hill.

Committee on Publication—Messrs. Aitken, Seares, von Geldern.

Library Committee—Messrs. Seares, Geo. C. Edwards, Miss O'Halloran.

Committee on the Comet-Medal—Messrs. Schaeberle (*ex-officio*), Pierson, Burckhal

OFFICERS OF THE CHICAGO SECTION.

Executive Committee—Mr. Ruthven W. Pike.

OFFICERS OF THE MEXICAN SECTION.

Executive Committee—Mr. Francisco Rodriguez Rey.

NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provi
the annual subscription, paid on election, covers the *calendar* year only. Subsequent
payments are due on January 1st of each succeeding calendar year. This rule is nece
order to make our book-keeping as simple as possible. Dues sent by mail should be dir
Astronomical Society of the Pacific 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of t
lications for the year in which he was elected to membership and for all subsequent ye
there have been (unfortunately) any omissions in this matter, it is requested that the Sec
be at once notified, in order that the missing numbers may be supplied. Members are re
to preserve the copies of the *Publications* of the Society as sent to them. Once each yea
page and contents of the preceding numbers will also be sent to the members, who can th
the numbers together into a volume. Complete volumes for past years will also be sup
members only, so far as the stock in hand is sufficient, on the payment of two dollars per
to either of the Secretaries. Any non-resident member within the United States can
books from the Society's library by sending his library card with ten cents in stamps
Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the

The Committee on Publication desires to say that the order in which papers are pr
the *Publications* is decided simply by convenience. In a general way, those papers are
first which are earliest accepted for publication. It is not possible to send proof sheets of
to be printed to authors whose residence is not within the United States. The responsibi
the views expressed in the papers printed rests with the writers, and is not assumed
Society itself.

The titles of papers for reading should be communicated to either of the Secretaries
as possible, as well as any changes in addresses. The Secretary in San Francisco will
any member of the Society suitable stationery, stamped with the seal of the Society, at cos
as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envel
cents. These prices include postage, and should be remitted by money-order or in U. S.
stamps. The sendings are at the risk of the member.

Those members who propose to attend the meetings at Mount Hamilton during the s
should communicate with "The Secretary Astronomical Society of the Pacific" at the ro
the Society, 819 Market Street, San Francisco, in order that arrangements may be m
transportation, lodging, etc.

PUBLICATIONS ISSUED BI-MONTHLY.

(February, April, June, August, October, December.)

GENERAL VIEW OF THE LICK OBSERVATORY ECLIPSE CAMP, NEAR JEUR, INDIA, JANUARY 22, 1898.

PUBLICATIONS

OF THE

Astronomical Society of the Pacific.

VOL. X. SAN FRANCISCO, CALIFORNIA, AUGUST 1, 1898. NO. 63.

A GENERAL ACCOUNT OF THE LICK OBSERVATORY-CROCKER ECLIPSE EXPEDITION TO INDIA.

By W. W. CAMPBELL.

The editor of this journal having requested me to furnish an account of the recent Lick Observatory Eclipse Expedition to India, I am glad to comply, on the understanding that no attempt shall be made to include the scientific results. While the expedition met with abundant success, the photographs have not yet been studied in the least. With practically every summer night clear for current observational work, the critical investigation of the eclipse plates must await the cloudy winter weather.

It has been the policy of the Lick Observatory to send out members of its staff to secure observations on the Sun's outer portions during all the available total solar eclipses. The eclipse of January 1, 1889, was observed in northern California by Messrs. KEELER, BARNARD, HILL, and LEUSCHNER; that of December 22, 1889, was observed at Cayenne, French Guiana, by Messrs. BURNHAM and SCHAEBERLE; that of April 16, 1893, was observed at Mina Bronces, Chile, by Professor SCHAEBERLE, and his volunteer assistants from many parts of the world. The Lick Observatory Expedition sent in Professor SCHAEBERLE's charge to observe the eclipse of August 9, 1896, in Japan, occupied four stations, but clouds obscured the Sun at all the stations.

The eclipse of January 22, 1898, began at sunrise in central Africa. The path of the shadow moved eastward to the Indian Ocean, thence inclining toward the northeast across India, ending

at sunset in Mongolia. The duration of totality was longest in the Indian Ocean, $2^m\ 20^s$. It decreased slowly from about $2^m\ 5^s$ on the west coast of India to about $1^m\ 20^s$ on the northeastern frontier of that country. The most available points for observations were in western India, with Bombay as the port of entry and base of supplies. Not only was this region the most accessible from the well-established routes of travel, but, what is more important, the astronomical conditions were the most favorable. The altitude of the Sun would be the greatest, from 50° to 52°, and there was the least probability of interference from clouds. January is in the "dry season" of India. The splendid report on the meteorology of the eclipse path prepared by the English Government in India showed that the weather in western India in January is very much like our beautifully clear weather on Mt. Hamilton in July and August. That eclipse parties would be favored with clear skies was almost a certainty. In view of these facts, it was not considered that the great distance — half-way around the globe — was an element in the question of sending an expedition to that country.

The late Colonel C. F. CROCKER, who had so generously defrayed the expenses of the earlier expeditions to Cayenne and Japan, expressed his interest in keeping up this line of work, and his willingness to provide means not only to send the expedition to India, but also for securing a substitute at Lick Observatory for the absent astronomer. This magnificent offer was made only a few days before his untimely death. The Board of Regents, of which Colonel CROCKER was a member, accepted the offer with gratitude, and authorized me to proceed to India and establish a suitable observing-station.

It was thought best not to interrupt my regular work of determining stellar velocities in the line of sight; and as my substitute to carry on that work did not arrive until toward the middle of August, there remained but two months in which to make preparations. Professor HOLDEN kindly placed the instrumental and mechanical resources of the Observatory at my disposal, so far as they could be spared. Deficiencies in our equipment were generously filled in by loans from friends of the Observatory. Thus the excellent Dallmeyer portrait-lens used at previous eclipses was again placed at our disposal by the Hon. WILLIAM M. PIERSON. Princeton University, through Professor YOUNG, loaned us its train of four compound prisms

and several minor pieces of apparatus. Aside from the clock in the 6-inch equatorial mounting, the Observatory could not well spare other driving-clocks. Two additional ones were imperatively needed, and they were supplied by loans from Professor HUSSEY and Mr. L. C. MASTEN. To save time, the four new spectrographs designed by me for the use of the expedition were mounted in wood (Spanish cedar) from my drawings, by the Observatory carpenter. In transit to India *via* Singapore and Colombo, these wooden mountings passed through a climate so moist and hot that it resembled a steam-bath. In India they were exposed for six weeks to the direct rays of the blazing sun, and to a remarkably dry atmosphere. That they worked satisfactorily is due to the quality of the wood and the excellent workmanship of the carpenter.

The experience of Professor SCHAEBERLE in Chile left no doubt in my mind that there would be an abundance of willing and able volunteer assistants in India to man all the instruments I could take with me. It was decided to take nine instruments, all for photographic use, as follows:—

A.—Three spectrographs for recording the spectrum of the Sun's edge, continuously, for a few seconds at the beginning of totality, and a few seconds at the end of totality, by means of plate-holders moving at a uniform rate by clockwork. This was a process which I had invented for use at the Japan eclipse, but personal reasons prevented me from taking that trip. As it was not known how bright the spectrum of the Sun's edge would be, I devised three instruments, whose proportions were such that the resulting intensities of their spectra would be very different, hoping that if one instrument under-exposed the spectrum, another would give the proper exposure. Two of these instruments were mounted on the 6-inch equatorial mounting, and the third on a large "polar axis."

B.—A spectrograph for recording the bright coronal line 1474 K, using light from the equatorial region of the corona both east and west of the Sun, to determine the displacement of the bright line due to motion in the line of sight, and thence to determine the law of rotation of the corona. Previous attempts to solve this problem made use of the violet calcium lines H and K; but as there was good reason to believe that those lines were not coronal, I decided to use the 1474 K line, which, to a great extent at least, is truly coronal. This line lies in a part of the

spectrum for which photographic plates are not very sensitive. Furthermore, to secure the dispersion sufficient for solving this problem, six prisms were necessary. The loss by reflection and absorption in such a prism train would be very great. The brightness of the line itself could not be estimated, since so few of those who had previously observed the line had published the constants of their instruments. Again, it was uncertain from the published observations whether the line was of fairly constant brightness, or varied widely for different eclipses. The prospect of photographing the line with my instrument was not promising, but merited a trial.

C.—A very efficient one-prism spectrograph, for recording the bright-line spectrum of the corona, for recording the continuous and possible dark-line spectrum of the corona, and incidentally the position of the maximum photographic brightness of the continuous spectrum.

D.—The 40-foot camera designed by Professor SCHAEBERLE, and used by him so successfully at the Chile eclipse. He had used the Clark 5-inch photo-heliograph lens. It seemed to him desirable to have a 6-inch lens for this camera, and such a lens was secured by the Observatory. But, when I tested it, defects were found to exist, such that its use was not warranted. There was not time to remedy the defects, and it was decided to use the 5-inch lens. In designing the carriage and track for the movable plate-holder, I followed the simple and practical plans used by Professor SCHAEBERLE. The purpose of this camera was to secure photographs of the inner corona on a large scale, with exposures of moderate length. The Moon's image with it would be nearly 4⅝ inches in diameter.

E.—The Floyd photographic telescope, of five inches aperture and about sixty-eight inches focal length, mounted on the "polar axis," for recording the general features of the corona. It is a splendid instrument for the purpose.

F.—The Dallmeyer portrait-camera, of 6-inch aperture and 33-inch focus. This is a valuable instrument for recording the outer corona, on a small scale, and for recording any strange object that may happen to be within a few degrees of the Sun. This camera was likewise to be mounted on the polar axis.

G.—An ordinary camera of 11-inch focus and 1⅜-inch aperture, the lens giving splendid definition over a very large field. This instrument was intended to supplement in a general way the Dallmeyer lens.

The polar axis, which carried five instruments, was a strong plank box, twelve by fifteen inches in section, and nine feet long, mounted parallel to the Earth's axis, on steel pivots at each end, running in roller bearings. From the middle of one side of the box a strong arm, thoroughly braced in every direction, ran out ten feet, at right angles to the box. On the outer end of the arm a sector of 10-foot radius was fastened. A clock securely mounted very close to the sector released a cord which pressed against the face of the sector, and lowered it at a uniform rate. It will be evident that an astronomical driving-clock applied at the end of a 10-foot arm would give splendidly uniform motion to the instruments attached to the axis. The polar axis formed a packing-case to and from the eclipse.

All the instruments were set up at Mt. Hamilton, and adjusted as far as necessary to test thoroughly all the parts. They were then taken to pieces, and packed as closely as was consistent with safety, along with sextant and chronometer, American ephemerides, thermometers, barometer, a good set of carpenters' and machinists' tools, nails, screws, photographic plates, implements and chemicals, a tent, etc. This whole equipment, in its packing-cases, formed a volume of only eighty-one cubic feet. It was so carefully packed, and so delicately handled *en route* to camp, that it arrived in perfect condition. The transfers of the freight occurred under my personal direction, and it may be said that the freight-handlers at nearly all points were easily persuaded to move the boxes with great care.

I was accompanied by Mrs. CAMPBELL and Miss ROWENA BEANS of San Jose, as volunteer observers traveling at private expense. We left San Francisco October 21, 1897, on the steamship *China* of the Pacific Mail Company. The company kindly offered to stow the instruments in the baggage room of the ship, where they lay at ease in the roughest weather. The twenty-eight-day voyage from San Francisco to Hongkong will always be recalled with the utmost pleasure, in spite of the fact that essentially all the rough weather experienced by us in our trip around the world occurred on the Pacific Ocean. The fine sailing qualities of the *China*, the superior discipline maintained by the captain and officers, the splendid service and comfort provided for all, were more than ever apparent after we had sailed the Indian Ocean, the Red and Mediterranean seas, and the North Atlantic.

As we sailed into Honolulu on a beautifully clear day, the water's surface was a mirror, and all the islands above our horizon were in clear view. We saw nothing on our trip to surpass these islands in natural charm. The extinct volcanoes near the city of Honolulu, known as the Punch Bowl and Diamond Head, were wonderfully interesting, though they were, of course, vastly inferior to the famous living volcano on one of the distant islands.

Our route westward from the Hawaiian Islands lay close to the thin chain of islands which extends nearly to Japan. A few of these islands have been woven into the plots of ROBERT LOUIS STEVENSON'S novels; and many a traveler on these waters has broken a spell of oppressive loneliness by recalling the story of *The Wreckers*, with blessings on the incomparable STEVENSON.

We stopped in Japan as the steamer stopped: one day each at the ports of Yokohama, Kobe, and Nagasaki. Excursions to Tokyo, Osaka, and Mogi were made from those points. Our stay in this fairyland was altogether too short; but the trip was not for pleasure, and we went on with the instruments. The weather in Japan had been perfect; and the absolutely unrivaled sunrise effects on their sacred mountain Fuji on two mornings, the views of the smoking volcano on Vries Island, of the Inland Sea, of the people and their art-treasures, these will remain with us as priceless memories.

The steamer ascended the Yangtse-Kiang River to Woosung, the port of entry for Shanghai. We spent a day in that interesting city,—mostly in the foreign business quarter, it is unnecessary to say. A brief trip into the native walled city was a revelation to me as to how the other half lives, in reckless defiance of all sanitary laws. Our friends living in the modern quarters of Shanghai were ready to do anything for our entertainment, except to accompany us into the native walled city of filth and contagion.

The trip to Hongkong was stormy. We passed through a genuine typhoon, which was not without its dangers. The ship was due to arrive at Hongkong on November 19th, and a P. & O. steamer, which we hoped to sail on to Bombay, was to leave there at noon of the 18th. The *China* entered the harbor on the 18th, at 10 A. M., and, thanks to the assistance of Captain SEABURY, we were at once transferred to the P. & O. steamer *Ancona*, and

started on the second stage of our journey, a seventeen-day trip to Bombay. The instruments were again placed in the baggage-room, and we were the recipients of many favors from the kind and gentlemanly officers. But as to the ship, the discipline, the service, and the food, the less said the better. The only item that was first-class was the price of the passage ticket.

Opportunities for seeing Singapore, Penang, and Colombo very well were afforded by the stopping of the steamer at those ports. Likewise, there was time for a quick trip to Kandy, near the center of the island of Ceylon. The wonderful vegetation of Ceylon was a revelation, even after seeing Honolulu and Singapore.

We arrived in Bombay on December 5th, having been forty-five consecutive days on the ocean voyage from San Francisco.

The English Government in India had made every possible preparation to assist the eclipse expeditions, of which ours was the first to arrive. Intending observers had been supplied early in the year with meteorological reports, with large-scale trigonometrical maps covering the regions of possible observing-stations, with data relating to railway transportation, camping-outfits, etc. From these I had decided to locate on the central line of totality a few miles north of Karad, a station about one hundred miles south of Poona. This would bring us in the high eastern foothills of the extensive range of mountains known as the Western Ghats. The contour lines on the maps showed that there would be no trouble in selecting a steep hillside on which to mount the 40-foot camera so that the tube of it would lie near the surface and the lens would require only a short support. This region would be easily accessible from the Southern Mahratta Railway and thence by bullock-cart. Water promised to be plentiful and near at hand. All the mountings of the instruments had therefore been constructed for the latitude of Karad, without a thought that the station could not be occupied.

On arriving at Bombay, I was informed by the government representatives that the bubonic plague was raging at Karad, and that the idea of locating there must be given up, not only on account of the danger to ourselves but because it would be out of the question to retain servants. The small army of servants whom we would have to employ and depend upon would stampede without warning if plague threatened the camp. So it seemed best to select another station. For many reasons the

OFFICERS OF THE SOCIETY.

Mr. R. G. Aitken . . . . *President*
Mr. C. B. Hill . . . . *First Vice-President*
Miss R. O'Halloran . . . . *Second Vice-President*
Mr. F. H. Seares . . . . *Third Vice-President*
Mr. C. D. Perrine, Mr. F. R. Ziel . . . . *Secretaries*
Mr. F. R. Ziel . . . . *Treasurer*

Board of Directors—Messrs. Aitken, Hill, Keeler, Molera, Miss O'Halloran, Messrs. Perrine, Pierson, Seares, St. John, von Geldern, Ziel.

Finance Committee—Messrs. Pierson, von Geldern, Hill.

Committee on Publication—Messrs. Aitken, Seares, von Geldern.

Library Committee—Messrs. Seares, Geo. C. Edwards, Miss O'Halloran.

Committee on the Comet-Medal—Messrs. Schaeberle (*ex-officio*), Pierson, Burckhalter.

OFFICERS OF THE CHICAGO SECTION.

Executive Committee—Mr. Ruthven W. Pike.

OFFICERS OF THE MEXICAN SECTION.

Executive Committee—Mr. Francisco Rodriguez Rey.

NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book-keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the *Publications* for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of two dollars per volume to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to the Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the card.

The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States. The responsibility for the views expressed in the papers printed rests with the writers, and is not assumed by the Society itself.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery, stamped with the seal of the Society, at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific" at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.

PUBLICATIONS ISSUED BI-MONTHLY.

(February, April, June, August, October, December.)

The Mamlatdar of Karmala, the highest official in the Taluka (district of) Karmala, had been instructed by the Bombay Government to look after the wants of the eclipse parties in his district. He was a very able man, practical, and constant in attendance. Our difficulties had a way of dissolving whenever he appeared. But for him we should have suffered many a discomfort in the desert. The Mamlatdar of Karmala is an Indian gentleman, of whose friendship we were and are proud. We shall remember him not only as a most able and faithful official, but as a friend in need.

The instruments, tents, supplies, and servants arrived in camp December 13th. After a day or two spent in pitching tents, establishing camp, etc., I was relieved of all care in regard to our daily wants and comfort, and that was fortunate, since the absence of skilled labor in that region required me to do everything myself that needed any degree of accuracy. The mounting of the 40-foot camera, which promised to be an easy matter in the mountains of Karad, was a genuine problem on the plains at Jeur. The lens at its upper end would be thirty-one feet higher than the plateholder and about thirty-three feet above the observer's platform. I decided to sink the plateholder end into a deep pit — say twelve feet — and thereby bring the lens within twenty feet of the ground. Six or eight native laborers were set to excavating the pit. Their implements were little picks and hoes poorly mounted, with shallow pans to remove the dirt from the pit. The government officials instructed me to pay them two annas — four cents American — each, per day, and thousands of laborers could have been secured at such wages. But time was an object with me, and I paid them three annas each, in consideration of their putting in a long day, of about seven hours. Six cents a day was a princely sum to these fellows, and to receive such wages raised them very high in the estimation of their neighbors. Unconsciously, I was making trouble; for when the other eclipse expeditions located in that vicinity, the laborers demanded from them the same wages that CAMPBELL Sahib was paying. In a couple of weeks, under my hourly admonition to *jildy*,— hurry up,— the men had sunk the 10 x 10-foot pit down to a depth of eight feet. The soil was dry from lack of rain, and almost rock-like, and I decided to go no deeper. I had ordered teak lumber and nails from Poona, a hundred miles away, for the construction of a tower to carry the

lens. The native carpenter whom I hired to assist me was very much in the way, and was kept only three hours. I built a very strong tower, about twelve feet square at the base, fourteen inches square at the top, and twenty-four feet high, with diagonal bracing on the four inclined faces and in the interior. Upon the inclined top a plank was fastened, which projected into the tube and carried the object-glass. The upper end of the tube did not touch the tower or lens-support, but was sustained by a separate wooden pillar. The lower end of the tube was fastened to the firm soil by iron pins, and the whole tube was held in place by wire cables in duplicate. The plate-carriage track was rigidly mounted at the bottom of the pit, quite independent of the tube. The wind could vibrate the tube without jarring either the plate-holder or object-glass. It was necessary to protect the tower from wind-vibrations. The lower end of it was firmly imbedded in a heavy stone wall, filled in with soil, to a height of about nine feet. That left the upper fifteen feet still exposed to the wind. I built a second tower, whose sides were about eighteen inches from the sides of the inner tower, and slightly higher. It was held in position by duplicate cables, so that it could not be blown into contact with the inner tower. A large canvas tent-fly was stretched over the south, east, and north faces of the outer tower, extending from above the lens to below the top of the stone wall. As the prevailing winds were from the southeast and east, the lens needed no further protection. On several days, just prior to the eclipse, fairly strong winds were blowing at the time when the Sun's image swept across the plate-holder, but not the slightest vibration of the lens could be detected.

The other eight instruments were mounted rapidly, though many changes and additions were made, involving the use, I believe, of every tool taken with me. The adjustments to focus, etc., were completed on January 16th, six days before the eclipse date.

As stated above, I was trusting to volunteer observers to man the instruments. When I first arrived at Bombay, many of the government officials said it would be impossible to secure volunteer assistants from among the army, navy, or civil officers, as they were not accustomed to such service. We had not been in Bombay many days, however, before offers came in abundance. Between twenty-five and thirty offers were received from men of thorough scientific training. The total number of observers

required to manage the instruments was twelve, or nine in addition to the three who had gone out from California. The abundance of volunteers made a choice almost embarrassing. I was even obliged to decline offers from two very able and enthusiastic amateur astronomers residing in India.

In addition to Mrs. CAMPBELL and Miss BEANS, I was assisted by Captain HENRY L. FLEET, Royal Navy, in charge of Her Majesty's marine forces in the Bombay harbor; by the commanders of three of his torpedo-boats, Lieutenant KINEHAN, R. N., Lieutenant MANSERGH, R. N., and Lieutenant CORBETT, R. N.; by Engineer GARWOOD, R. N.; by Major BOILEAU, Royal Engineer; by the Rev. J. E. ABBOTT, who had been a student under Professor YOUNG at Dartmouth College; by the United States consul at Bombay, Major S. COMFORT, and Mrs. COMFORT.

The volunteer observers arrived in camp from January 17th to 20th. All of them were assigned to responsible positions, and it was a pleasure to drill them in the details of the programme. The final drill occurred the evening of January 21st, with every observer perfectly at ease in his assigned work.

On the 21st, all the clock cords were carefully examined, and some of them renewed. The cameras, plate-holders, etc., were tested for leaks which might let in the light, and all the adjustments were verified. Some mysterious forces had disturbed the adjustments of the 40-foot camera plate-carriage tracks in the bottom of the pit, and the very important clock which rotated the polar axis, on the night of January 20th. Fortunately, the disturbances were so marked that they were noticed by me just before beginning the rehearsal on the afternoon of the 21st. As the Sun passed through the region of the sky which the eclipsed Sun would occupy the following day, I had time enough, and just enough, to readjust these very essential parts. I had not been aware that animals came around the camp at all, but, to guard against a similar occurrence, on the night of the 21st, Captain FLEET suggested that he and the other observers should do guard duty at the instruments throughout the night. Every one entered into the plan with enthusiasm, and the instruments were all right on the morning of the eclipse.

The plate-holders were filled the night of the 21st, most of the plates being "backed" with black liquid backing.

The final examination of the instruments was made the morn-

ing of the eclipse, to see that no cobwebs or dust could interfere with the proper passage of the light. The wind-breaks of floor-rugs, on bamboo poles, were put up by the naval officers. Sextant observations of the Sun for determining the correction to the chronometer were made and reduced, and the chronometer times for the beginning and ending of totality were computed. Our preparations were completed about two hours before totality. Although there were one or two thousand excursionists at Jeur, from Bombay, Madras, and elsewhere, they were not allowed by the government officials to come near the eclipse camps, nor were the natives allowed to leave their villages to come to the camp, so that our surroundings were favorable. We were in camp seven weeks, and I should say the eclipse day was the most perfect of all. There had been more or less wind on previous days, but the 22d was perfectly calm. The atmospheric conditions were all that could be wished for. The observers took their places a few minutes before the time of totality. Captain FLEET and Engineer GARWOOD in the 40-foot camera; Lieutenant CORBETT at the chronometer, just outside the large camera, and near the polar axis; Lieutenant KINEHAN and Miss BEANS at the Pierson camera; Lieutenant MANSERGH and Major COMFORT at the Floyd telescope; Mrs. COMFORT at the 11-inch camera; Mr. ABBOTT at the 6-prism spectrograph; Major BOILEAU, at the grating spectrograph; and Mrs. CAMPBELL and myself at the two spectrographs on the equatorial mounting. There was no nervousness discoverable in the party. Lieutenant CORBETT was to give the signal at twenty seconds before totality, for Major BOILEAU and myself to start the moving plate-holders of the three spectrographs, to record the varying spectrum of the Sun's edge, as the edge was gradually covered by the Moon. Captain FLEET, in the 40-foot camera, was to give the signal "Go" at the instant when the corona flashed out at the vanishing-point of the cresent Sun, at which signal the chronometer count was to begin, along with the programmes of the four cameras and the two additional spectrographs. The programme of signals and exposures was carried out by the observers without nervousness or excitement, as well as if they had been professional observers of eclipses. The spirit of the observers may be illustrated by one or two circumstances. I had constructed a small annex tent in the pit of the 40-foot camera, into which the observers, Captain FLEET and Mr. GARWOOD, could go and look a few seconds at the

corona. They refused to do so, and did not see the corona except as it was photographing on the 14 x 17-inch plate. Lieutenant CORBETT was asked to keep his eye on the chronometer during the first minute, and then feel free to count by sound as long as he cared to view the corona during the second minute. He did not take his eye off the second-hand during the whole of totality. Other instances of sacrifice of self to the success of the expedition could be mentioned. The same noble qualities came out on the days preceding the eclipse, and with such assistants I laughed at Failure. It is plain that no astronomer was ever more ably assisted by volunteer observers.

The eclipse began within a half-second of the computed time, and ended in the same way, lasting $1^m\ 59\frac{1}{2}^s$. The duration, computed from the American Ephemeris, was $1^m\ 59^s$; and from the English Nautical Almanac, was $2^m\ 5^s$.

It is impossible to describe the beauty of the Sun's surroundings. The corona was exquisite, more beautiful by far than anything else we saw in a journey around the world. It is well worth a journey to remote regions of the Earth to see.

The first illustration (Frontispiece) is a general view of the eclipse camp; and the second (page 134), taken a few minutes after the eclipse, shows the observers at their instruments, except those who had been in the 40-foot camera.

After the eclipse, the development of the plates was taken up. Previous experiments had shown that the chemical formulæ used at home could not be used in India. The formulæ were experimented with until one was obtained which gave good results. The weather in camp was very hot in the daytime, but grew rapidly colder at night, reaching a minimum about sunrise. The extremes were such as I had never experienced before. When the day temperature remains for hours at 92° or 93° Fahr., a night temperature of 42° seems bitterly cold. Yet this range of fifty degrees occurred several times while we were in camp. The heat was intense during the week following the eclipse, and greatly affected the photographic development. With a dark room composed of one tent inside another tent, it was necessary to wait until the atmosphere cooled down—from 1 A. M. till sunrise, and all the plates were developed in those hours. The negatives from all the instruments came out almost exactly as they were expected to, and the expedition was a success.

The instruments were quickly dismounted and repacked, the

photographs were packed with special care, and the tents and camp furniture were made ready for shipping. I can still see that long line of bullock-carts moving slowly out of our camp to the station. Our life there was so intense, among a people so strange and so interesting, that the *individual incidents* of the seven-weeks' camping experiences in central India will remain as vividly with us as the general effect of the whole.

When the instruments and photographs were safely stored in the specie-room of the Steamship *Socotra* at Bombay, *en route* to Hongkong, the eclipse was over, and we were ready to enjoy the wonders of Delhi, Agra, the Himalayas,—but that is not an astronomical story.

Our route homeward brought us *via* the observatories at Cairo, Rome, Florence, Milan, Nice, Paris, Greenwich, Tulse Hill, Kensington, Cambridge, Oxford, and Williams Bay, where we were the recipients of many kindnesses from busy astronomers.

I cannot close this account without a grateful acknowledgment of the services rendered to the expedition by the United States consul at Bombay, Major COMFORT. I know that our expedition was continually held in mind by him, both as the representative of our government, and as our valued friend. We were almost daily recipients of his assistance. The continual kindness shown us by Major and Mrs. COMFORT, by Captain and Mrs. FLEET, and by many others, contributed both to the success of the expedition, and to the pleasure of our visit in that wonderful country.

Three other eclipse parties were encamped near our station: the Japanese Government party from Tokyo; the Indian party from the Poona College of Science, under Professor K. D. NAEGAMVALA; and Professor BURCKHALTER, from the Chabot Observatory, in charge of the PIERSON expedition. Professor BURCKHALTER was just as enthusiastic in India as he is at home. Interchanges of visits between our camps were frequent, and gave us great pleasure. We were glad of his success, not only because he was our countryman, but because success was deserved.

THE INFLUENCE OF PHYSIOLOGICAL PHENOMENA ON VISUAL OBSERVATIONS OF THE SPECTRUM OF THE NEBULÆ.

By James E. Keeler.

According to the view almost universally accepted by astrophysicists, the stars have been evolved from pre-existing nebulæ by a gradual process of condensation. The view is an old one; but before the spectroscope was invented, it was necessarily based on very simple data, derived from observations of the forms of nebulæ as seen in the telescope. The spectroscope opened up an entirely new method of attack. Used in connection with the great telescopes of modern times it has furnished an immense mass of data, and the study of the different types of stellar spectra and their probable connection with the order of stellar evolution has become an exceedingly complicated and interesting branch of astronomical science.

In a general way, it may be said that the evidence brought to light by the spectroscope is in harmony with the views which had already been held, though it would not be difficult to point out numerous difficulties and contradictions. As the spectrum of the nebulæ is regarded as the signature of the earliest stage of stellar evolution, it is not surprising that astrophysicists have attached special importance to it in their studies, and that they view every discovery or investigation relating to it with the greatest interest.

A discussion has recently been carried on in the *Astrophysical Journal* and the *Astronomische Nachrichten*, with reference to the part played by physiological causes in visual observations of the bright lines in nebular spectra. The spectrum of a nebula contains many bright lines, most of which are, however, very faint, and are revealed by long-exposure photographs only. Ordinarily only a few lines are seen—one at λ 5007, (the "chief" nebular line), one at λ 4959, probably due to the same unknown substance as the preceding, and in addition to these, some of the lines of hydrogen and helium. Some years ago, Professor Campbell, while observing the Great Nebula of *Orion* with the thirty-six inch telescope, found that the spectrum was different in different regions. In the central and brighter parts of the nebula, the greenish-blue hydrogen line F, or $H\beta$, was about as bright as the

second nebular line λ 4959. In the faint and remote region surrounding the star *Bond* 734, all the lines were of course faint, but the Hβ line was at least five times brighter than even the chief nebular line, while the second line was quite invisible.

These observations of Professor CAMPBELL (which have been confirmed by various members of the Lick Observatory staff, and by the eminent spectrocopist, Professor RUNGE of Hanover, Germany, while on a visit to Mt. Hamilton) were regarded by him as indicating a real difference in the distribution of the materials of which the nebula is composed. The substance, whatever it may be, which gives the principal lines in the green, is more strongly concentrated in the central regions of the nebula; in the faint and remote regions, hydrogen is predominant. In a previous number of these *Publications*,* I have pointed out the fact that these differences of distribution of the substances in the nebula (assuming them to be real), must lead to a difference between the forms of the nebula as shown in drawings and in photographs.

Professor SCHEINER, of the Astrophysical Observatory at Potsdam, holds, on the contrary, that the spectrum of the *Orion* nebula is the same in all its parts, and attributes the differences observed by Professor CAMPBELL to physiological causes. By what is known as the "Purkinje effect," the maximum of brightness in the spectrum shifts toward the violet end when the intensity of the light is diminished. If, therefore, we suppose that two lines, one red and one blue, are equally bright when the intensity of the illumination has a certain value, the red line will appear brighter than the blue if the intensity is increased, and the blue line will appear brighter than the red if the intensity is diminished. The blue line may even be distinctly seen after the red line has faded into invisibility.

In Professor SCHEINER'S opinion, the observations of Professor CAMPBELL are sufficiently explained by this physiological effect, as well as the fact that the red hydrogen line C or Hα has been observed in very few nebulæ. His views were confirmed by some photometric observations which he made on the artificial spectrum of hydrogen.

In connection with these observations, Professor SCHEINER, extending some earlier researches of KOCH, made some experiments in which he sought to ascertain the possible influence on

* No. 44.

the spectrum of the temperature of the surroundings under which hydrogen emits light. The hydrogen was enclosed in a vessel which was cooled down to a temperature of — 200° C. by means of liquid air, and it was made luminous by extremely feeble electric waves. The temperature of the hydrogen under these conditions approached the absolute zero — 273° C., but its spectrum was the same as that observed at ordinary temperatures. Hence, there seems to be no reason to suppose that the spectrum of hydrogen in the nebulæ is influenced by the cold of surrounding space.

It will be seen that the apparent shifting of the brightness in the spectrum, due to the Purkinje effect, is in the right *direction* to explain the observations of Professor CAMPBELL on physiological grounds, since these observations showed that the more refrangible line was relatively brighter in the faint regions of the nebula. In my opinion, however, the Purkinje effect is inadequate to explain the *amount* of the observed variations of brightness. Professor SCHEINER'S experiments dealt with an extreme case. The lines compared ($H\alpha$ and $H\beta$) were widely separated, and the physiological effect was strongly marked. But in Professor CAMPBELL'S observations, verified by Professor RUNGE, the lines compared were in nearly the same spectral region, so that the physiological effect must have been very much smaller; yet the variation of the relative brightness of the lines was from twenty to thirty-fold. It is difficult to avoid the conclusion that we are here dealing with actual differences in the radiation from different regions of the nebula.

When the *Orion* nebula again comes into position for observation with the great telescope, it will be easy to make an experiment in which physiological effects are wholly eliminated. With the spectroscope slit placed on the bright region near the trapezium, the intensity of the light can be diminished (say by reducing the vertical aperture of the spectroscope) until the second nebular line (λ 4959) is barely visible, or about as bright as it is with full aperture in some remote region of the nebula. Under these circumstances, any considerable differences in the relative brightness of the $H\beta$ line could not be ascribed to physiological causes. Photography could perhaps be made to furnish a still more satisfactory test.

I am further not quite convinced that the invisibility of the $H\alpha$ line in the spectrum of the great majority of nebulæ is entirely

due to the Purkinje effect. It is easy enough to reduce the visible hydrogen spectrum, derived from spectrum tubes, to the single line Hβ, by merely diminishing its brightness; but to my eye, at least, Hγ always disappears before Hα. In the nebulæ, on the other hand, Hγ is seen without difficulty, while Hα is generally invisible. In some stars we find hydrogen exhibiting certain spectral peculiarities which have not yet been produced artificially, and certainly there is nothing absurd in the supposition that hydrogen in the nebulæ can have a spectrum which differs in some respects from that obtained in our laboratories. The difference, if it is real, as I believe it to be, may be a key which will finally unlock some of the many mysteries by which the nature and constitution of the nebulæ are still surrounded.

WOLF'S PERIODICAL COMET.

By W. J. Hussey.

On the night of June 16th, I turned the 36-inch refractor to the place given by Thraen's ephemeris of Wolf's periodical comet (*Astronomische Nachrichten*, No. 3484), and at once found it at less than its own diameter from its predicted place. My observation at the time of rediscovery gives the following position, which is already corrected for parallax and aberration:—

Greenwich M. T.	True α	True δ
1898 June 16.95449	$2^h\ 16^m\ 18^s.68$	$+19°\ 42'\ 46''.3$

For the same epoch, the position which I have obtained by computation from Thraen's elements of the orbit is only $1^s.31$ larger in right ascension and only $1''.1$ smaller in declination. These residuals are remarkably small, and show that Thraen has reached most excellent results in his determination of the definitive elements of the orbit.

This comet was first seen as a nebulous body by Max Wolf at Heidelberg, September 17, 1884, and its cometary nature was fully established by him on September 18th and 19th. He then notified the Strassburg Observatory of his discovery, and the first accurate position of the comet was obtained there on September 20th. On September 22d the comet was discovered independently at the Dun Echt Observatory by Ralph Copeland, who detected it "as a gaseous body with the spectroscope." The

telegram announcing the discovery by WOLF was not delivered at the Dun Echt Observatory until the morning of September 23d. It is of interest to note that the first observation of the comet in this country was that obtained at Washington by Commander (now Acting Rear-Admiral) WM. T. SAMPSON, of the U. S. Navy, who was then in charge of the 9.6-inch telescope of the Naval Observatory.

At the first apparition the various observers described the comet as a bright nebulous body, about 2′ in diameter, having a strong central condensation, almost stellar in appearance, and equal in brightness to a star of from the 8th to 11th magnitude. It had scarcely a trace of a tail; many observers did not note any at all, but described the comet as being very nearly round. Spectroscopic observations were made at Nice and Rome. The observations at Nice, towards the end of September, showed a bright continuous spectrum crossed by the three usual carbon bands. At Rome apparently only the middle (and brightest) of these bands was seen.

The comet had been under observation only a short time, when it was found that the observed places could not be satisfactorily represented on the supposition of parabolic motion. Elliptic elements were accordingly computed by KRUEGER, CHANDLER, WENDELL, ZELBR and THRAEN. Their results showed the comet to be one of short period, requiring about 6¾ years to complete a revolution about the sun. It was also noticed that the comet had been so near *Jupiter* from March to August, 1875, as to experience very marked perturbations. LEHMANN-FILHÈS undertook the investigation of the changes in the elements resulting from these perturbations. Basing his work on KRUEGER's elements, which were admittedly only approximately true, he found that the axis of the orbit had been turned through an angle of nearly 27°, that the inclination had been diminished more than 2°, the eccentricity had been doubled and the periodic time shortened over two years. Moreover, the perihelion distance had been changed from about 309,000,000 to 146,000,000 miles, showing that prior to 1875, the comet had at all times been so distant from the earth as to be either invisible or at least be so faint as to be readily overlooked, thus accounting for its not having been discovered before that time.

These circumstances gave the comet a wide interest among astronomers. It was observed a long time at many observatories.

During the first apparition no less than 950 observations were secured at some fifty-four different observatories, from September 20, 1884, to April 6, 1885. During these six and one-half months the comet described 106 degrees of its heliocentric arc, 35° before and 71° after perihelion passage. Numerous observations were obtained toward the close of the apparition, thus strengthening greatly that part of the arc and giving the final elements greater security. The definitive elements were computed by THRAEN, and both he and L. STRUVE computed the perturbations between the first and second apparitions, and provided ephemerides by means of which SPITALER rediscovered the comet, May 1, 1891.

At the second apparition the comet again remained visible for a long time, until March 31, 1892, and no less than 681 observations at thirty-three different observatories were obtained. THRAEN again computed the definitive elements, making use of the data of both the first and second apparitions and taking into account the perturbations of the Earth, *Mars*, *Jupiter* and *Saturn*. The elements which he finally obtained, when referred to the ecliptic and the mean equinox of 1898.0, are as follows:—

Epoch and Osculation 1898 August 22.0 Berlin M. T.

$$\left.\begin{array}{rl} M = & 6^\circ\ 58'\ 11''.03 \\ \omega = & 172\ \ 52\ \ 35\ .77 \\ \Omega = & 206\ \ 27\ \ 22\ .26 \\ i = & 25\ \ 12\ \ 16\ .59 \\ \phi = & 33\ \ 44\ \ \ 2\ .15 \end{array}\right\} \begin{array}{c}\text{Ecliptic and} \\ \text{Mean Equinox of 1898.0}\end{array}$$

$$\mu = 518''.36764$$

$$\log a = 0.5569125$$

The accuracy of these elements is very great, as is shown by the close agreement of the computed and observed places of the comet at the time of its rediscovery this year, and they reflect great credit upon their author.

MT. HAMILTON, July 11, 1898.

COMET *c*, 1898 (CODDINGTON).

BY E. F. CODDINGTON.

On the evening of June 9th, I made an exposure of two hours with the Crocker photographic telescope, for the purpose of obtaining a photograph of the extensive nebulous region to the

DISCOVERY-PLATE OF COMET CODDINGTON.

1898, June 9d 9h 20m to 11h 45m P. S. T.

north of *Antares* in the constellation *Scorpio.* At the time changes were being made in my darkroom, and it was not until June 11th that I had an opportunity to develop the plate. When the plate was developed a strong trail, about one-sixteenth inch in length, was found upon it, some two or three degrees north-east of *Antares.* The length and direction of the trail indicated the possible positions in which the object might be found, and on turning the 12-inch telescope to the proper region the comet was picked up immediately, and observed for position by Professor HUSSEY.

At the time of discovery, the comet had a bright nucleus of about the 8th magnitude, surrounded by a nebulosity somewhat less than a minute of arc in diameter. The nucleus was very nearly stellar, and when examined with the 36-inch refractor, using a power of 1000, it presented a uniform appearance. There was a slight indication of a tail on one side of the nebulosity, but the comet was so near opposition that whatever tail it may have had, extended almost directly away from the comet in the line of sight. When discovered the comet was near *Antares* and since then it has been moving steadily towards the south-west, a little more than a degree per day. It is already too far south to be observed at most northern observatories. By the middle of August it will have reached a southern declination of 50 degrees and will then be in the constellation *Centaurus.* It will remain visible for some time to the observatories of the southern hemisphere.

This is the third comet which has been discovered by photography. On October 12, 1892, Professor BARNARD found the trail of a hitherto unknown comet upon a photograph of the Milky Way, which he had just obtained with the Crocker telescope.

Professor SCHAEBERLE was the next to discover a comet by means of photography. He found the image of some strange object on some of his eclipse negatives taken at Mina Bronces, Chile, in 1893, and verified its cometary nature by means of the plates taken by other eclipse parties. This comet was never observed visually, and its orbit is unknown.

The accompanying half-tone shows the trail of the comet and also gives a fair representation of a very remarkable region of the sky. At the lower central part of the reproduction is the bright star *Antares* with the cluster, *Messier 4*, just to the right. Just

above we find an area which stands out in a marked contrast to the surrounding region, by being almost void of faint stars. Instead we find a large nebula with its principal condensations surrounding the few bright stars that are situated here. A great deal of delicate detail can be traced on the original negative and the vacant lanes running eastward from this region are prominent features. The comet was crossing one of these lanes at the time of exposure. And it may be found on the accompanying illustration near the left margin. I hope to secure a better negative of this region. This one is reproduced on account of the comet trail.

Using the following observations:—

Mt. Ham. M. T.	app α	app δ	Observer
June 11, $9^h\ 13^m\ 7^s$	$16^h\ 24^m\ 56^s.21$	$-25°\ 14'\ 20''.0$	Hussey
13, 10 47 36	16 17 58 .38	-26 33 3 .3	Tucker
15, 8 43 30	16 11 23 .71	-27 45 12 .7	Hussey

Professor HUSSEY and I computed the following preliminary elements:—

$$T = 1898 \text{ Sept. } 10.3054 \text{ Gr. M. T.}$$

$$\left.\begin{aligned} \omega &= 229°\ 28'\ 11'' \\ \Omega &= 73\ \ 59\ \ \ 5 \\ i &= 71\ \ 17\ \ 49 \end{aligned}\right\} \begin{array}{c}\text{Ecliptic and} \\ \text{Mean Equinox of 1898.0}\end{array}$$

$$\log q = 0.24760$$

$$(\text{O—C}):\ \Delta\lambda' \cos\beta' = +\ 4'',\ \Delta\beta' = +\ 2''$$

From Mt. Hamilton observations of June 11th, 18th and 26th, I have computed the following elements of this comet. The mean of three observations was used in forming the middle place, and the mean of two observations for the last place.

$$T = 1898 \text{ Sept. } 13.97347 \text{ Gr. M. T.}$$

$$\left.\begin{aligned} \omega &= 233°\ 10'\ 31''.4 \\ \Omega &= 73\ \ 59\ \ 19\ .8 \\ i &= 69\ \ 56\ \ 47\ .3 \end{aligned}\right\} \begin{array}{c}\text{Ecliptic and} \\ \text{Mean Equinox of 1898.0}\end{array}$$

$$\log q = 0.231178$$

$$(\text{O—C}):\ \Delta\lambda' \cos\beta' = +\ 4''.7,\ \Delta\beta' = +\ 1''.8$$

MT. HAMILTON, July 11, 1898.

PLANETARY PHENOMENA FOR SEPTEMBER AND OCTOBER, 1898.

By Professor Malcolm McNeill.

September.

The Sun crosses the equator and autumn begins September, 22d, 4 P.M., P. S. T.

Mercury passes inferior conjunction on September 5th, and moves rapidly out toward greatest western elongation, which it reaches on September 21st. It may be seen as a morning star in the eastern twilight during the latter half of the month.

Venus is still an evening star and comes to greatest elongation on September 22d. Throughout the month it sets less than two hours after sunset. When a greatest eastern elongation occurs in the spring, the planet remains above the horizon more than twice as long after sunset. The reason for the difference is, that for an eastern elongation in the spring, the planet is far north of the Sun, and in the autumn it is far south, nineteen degrees on September 30th.

Mars is getting into more convenient position for observation, rising before midnight on September 1st, and nearly an hour earlier at the close of the month. It moves nineteen degrees eastward during the month through the constellation *Gemini*, and at the close of the month is only one degree from the third magnitude star δ *Geminorum*. The Moon makes a very close approach to *Mars* on the morning of September 9th, but will hardly occult it in this country, except possibly in the extreme southwestern portions. The planet is beginning to grow more conspicuous, and its distance from the Earth diminishes from 137,000,000 miles to 120,000,000 during the month.

Jupiter is still an evening star, but its distance from the Sun is rapidly diminishing, and it will scarcely be possible to see it with the naked eye after the first half of the month. It moves eastward and southward about seven degrees during the month, and is in the western part of the constellation *Virgo*, not far from *Spica*, the brightest star of the constellation.

Saturn is also an evening star and sets at 8:36 P.M., September 30th. It is in the constellation *Scorpio*, about seven degrees

to the north of the first magnitude red star *Antares*, and moves about two degrees eastward and southward during the month.

Uranus precedes *Saturn*, setting about half an hour earlier. It is not bright enough to be easily seen at the low altitude it reaches before the disappearance of the evening twilight.

Neptune is on the border on the constellations *Taurus* and *Gemini*, and rises before 10 P.M. at the end of the month.

OCTOBER.

Mercury remains a morning star until October 19th, when it passes superior conjunction and becomes an evening star. It may be seen in the early twilight for a few days after the beginning of the month, but it soon reaches a point too near the Sun for naked-eye observation.

Venus is an evening star. It is at its greatest possible southern latitude as seen from the Sun on October 9th, and this, combined with its position in regard to the ecliptic as seen from the Earth, gives it its nearly maximum southern declination. At the end of the month, it sets only an hour and a half after sunset. During October and November it will be very bright, the time of greatest brilliancy being about the end of October. For several weeks before and after that time, it will be bright enough to be seen in full daylight with the naked eye, if the low altitude of the planet due to its great southern declination does not interfere too much.

Mars rises about an hour earlier than during September, at a little after 10 P.M. on October 31st. It is in quadrature with the Sun on October 17th. It moves about fifteen degrees eastward and two degrees southward during the month through the constellation *Gemini* into *Cancer*. At the end of the month it will have diminished its distance from the Earth to less than 100,000,000 miles, and its brightness will increase about forty per cent during the month.

Jupiter begins the month as an evening star, too near the Sun to be seen without a telescope, and passes conjunction on October 13th. Toward the close of the month, it rises more than an hour before sunrise, the interval between the rising of the planet and Sun increasing quite rapidly, owing to the rapid motion of the Sun eastward and southward.

Saturn is still an evening star, but is not in very good position for observation, owing to its nearness to the Sun and its low altitude after sunset. At the end of the month, it sets less than two hours after the Sun.

Uranus is also an evening star, but as it sets half an hour earlier than *Saturn*, and is so faint, it can scarcely be seen without a telescope.

Neptune rises two hours earlier than in September, and is on the border of the constellations *Taurus* and *Gemini*.

Phases of the Moon, P. S. T.

			H. M.
Last Quarter,	Sept.	7,	2 51 P. M.
New Moon,	Sept.	15,	4 10 P. M.
First Quarter,	Sept.	22,	6 39 P. M.
Full Moon,	Sept.	29,	3 10 P. M.
Last Quarter,	Oct.	7,	10 5 A. M.
New Moon,	Oct.	15,	4 37 A. M.
First Quarter,	Oct.	22,	1 9 A. M.
Full Moon,	Oct.	29,	4 18 A. M.

The Sun.

1898.	R. A. H. M.	Declination. °	Rises. H. M.	Transits. H. M.	Sets. H. M.
Sept. 1.	10 43	+ 8 11	5 32 A. M.	12 0 M.	6 28 P. M.
11.	11 19	+ 4 27	5 41	11 56 A. M.	6 11
21.	11 55	+ 0 36	5 51	11 53	5 55
Oct. 1.	12 31	− 3 18	6 1	11 50	5 39
11.	13 7	− 7 8	6 11	11 47	5 23
21.	13 44	− 10 49	6 22	11 45	5 8
31.	14 23	− 14 13	6 33	11 44	4 55

Mercury.

Sept. 1.	11 6	+ 1 4	6 20 A. M.	12 23 P. M.	6 26 P. M.
11.	10 37	+ 6 31	4 53	11 15 A. M.	5 37
21.	10 50	+ 8 20	4 20	10 48	5 16
Oct. 1.	11 44	+ 3 49	4 51	11 3	5 15
11.	12 48	− 3 28	5 38	11 27	5 16
21.	13 50	− 10 44	6 27	11 50	5 13
31.	14 51	− 17 2	7 11	12 12 P. M.	5 13

Venus.

Sept. 1.	13 28	− 10 45	9 22 A. M.	2 45 P. M.	8 8 P. M.
11.	14 7	− 15 18	9 38	2 45	7 52
21.	14 46	− 19 21	9 53	2 45	7 37
Oct. 1.	15 24	− 22 45	10 5	2 43	7 21
11.	15 59	− 25 21	10 13	2 39	7 5
21.	16 30	− 27 6	10 11	2 30	6 49
31.	16 53	− 27 55	9 59	2 13	6 27

Mars.

Sept.	1.	5 56	+ 23 28	11 49 P.M.	7 14 A.M.	2 39 P.M.
	11.	6 23	+ 23 33	11 35	7 1	2 27
	21.	6 48	+ 23 24	11 21	6 46	2 11
Oct.	1.	7 11	+ 23 4	11 8	6 31	1 54
	11.	7 33	+ 22 36	10 52	6 13	1 34
	21.	7 53	+ 22 4	10 35	5 54	1 13
	31.	8 11	+ 21 31	10 15	5 32	12 49

Jupiter.

Sept.	1.	12 45	− 3 35	8 14 A.M.	2 2 P.M.	7 50 P.M.
Oct.	1.	13 8	− 6 2	6 47	12 27	6 7
	31.	13 32	− 8 28	5 22	10 53 A.M.	4 24

Saturn.

Sept.	1.	16 18	− 19 43	12 46 P.M.	5 34 P.M.	10 22 P.M.
Oct.	1.	16 25	− 20 7	10 55 A.M.	3 44	8 33
	31.	16 37	− 20 37	9 10	1 57	6 44

Uranus.

Sept.	1.	15 50	− 19 58	12 18 P.M.	5 7 P.M.	9 56 P.M.
Oct.	1.	15 54	− 20 11	10 25 A.M.	3 13	8 1
	31.	16 1	− 20 30	8 34	1 21	6 8

Neptune

Sept.	1.	5 37	+ 22 2	11 35 P.M.	6 54 A.M.	2 13 P.M.
Oct.	1.	5 38	+ 22 1	9 39	4 58	12 17
	31.	5 36	+ 22 0	7 39	2 58	10 17 A.M.

NOTICES FROM THE LICK OBSERVATORY.*

PREPARED BY MEMBERS OF THE STAFF.

THE NOVEMBER METEORS.

Harvard College Observatory Circular No. 31.

On the night of November 13, 1897, 91 meteors were observed at the Harvard College Observatory, and 47 meteors at an auxiliary station 12 miles south, the Blue Hill Meteorological Observatory. A discussion of these observations by Professor W. H. PICKERING will be found in the *Annals* of this Observatory, Volume XLI, No. 5. A much greater display of meteors is expected next year, and it is very important that a continuous watch should be kept during the two or three days in which the Earth is passing through the denser portion of the meteor stream. This can only be done by establishing a series of stations in various longitudes, so that during the entire time one or more of these stations shall fulfill the conditions that the radiant point shall be above the horizon and the Sun below. Correspondence is invited with astronomers and others willing to participate in this work, especially with those who will be in the less frequented longitudes. If the weather is favorable, and the plan here proposed is carried out satisfactorily, it is expected that all the observations will be discussed here and published in the *Annals* of this Observatory. To secure the best results, a uniform plan of work is essential. Maps and forms of record will be sent to all who early signify their readiness to take part in this work. The radiant point of the meteors indicated by the cross in the accompanying map [here omitted], will not rise in this latitude until $10^h\ 30^m$, and twilight interferes at about $5^h\ 30^m$ in the morning. As the shower sometimes begins before the predicted

* Lick Astronomical Department of the University of California.

date, a watch should be kept on November 11 and 12, from 11 to 1 o'clock, and if many meteors are seen, the observations described below, for November 13, should be made on these nights, and also on the nights following the shower.

Each observer is requested to devote his attention to the region within 25° of the radiant point, and included in the map, and to send the following data regarding his observations:—

Name of observer, location of station, post-office address, time of beginning and ending of observations, interruptions by clouds or other causes, condition of sky, as clear, hazy, passing clouds, etc.

The observations most desired are those required to determine the frequency of the meteors. They are of extreme simplicity, and need only care, system, and perseverance. Once an hour, or, better, once every half-hour, observe and record the time during which ten meteors appear. This is most easily done by noting the time by a watch and at exactly the beginning of a minute looking at the sky, giving it undivided attention and counting the meteors seen, not including those appearing outside the region covered by the map. If great numbers of meteors appear, it may be better to count a larger number, as twenty or even fifty. If the interval between the meteors is long, the number to be counted may be reduced. These observations should be repeated until dawn, or over as long an interval as possible. Between these observations, the observer may rest, or may make special observations of individual meteors. Thus, when a meteor is seen, record the hour and minute, the brightness on a scale of stellar magnitudes, −2, equals the brightness of *Jupiter*, or *Sirius;* 0, *Arcturus*, or *Vega;* 2, the *Pole-Star;* 4, the *Pleiades;* 6, the faintest star visible; the color, B=blue, G=green, Y = yellow, W = white, and R = red; the class, L=*Leonid*, if path prolonged would pass through center of map, N = other meteors. Thus, L 5 Y, $12^h\ 26^m$, indicates that a *Leonid*, magnitude 5, yellow in color, was seen at $12^h\ 26^m$. Find by trial beforehand how many seconds are required to make each record. Again, the path of each meteor may be marked upon the map by noting its position in relation to the adjacent stars. Such work can be done equally well elsewhere, and should not interfere with the hourly count mentioned above.

EDWARD C. PICKERING.

May 30, 1898.

DISCOVERY OF COMET *e* 1898 (PERRINE).

This comet was discovered in the morning of June 15th, in the constellation *Camelopardalis*. At $23^h\ 22^m\ 34^s$ G. M. T. of June 14th, the comet's position was $\alpha = 3^h\ 29^m\ 0^s.99$, $\delta = +58^\circ\ 35'\ 22''.3$. It was then moving slowly south and more rapidly east. The elements as computed from the first three observations will be found elsewhere in this number of the *Publications*. These elements bear considerable resemblance to those of the comet 1785 I, especially with regard to ω and ι, the resemblance being closer than was the case with the comet *b* 1898, pointed out in No. 62 of these *Publications*. Comet *e* 1898 appears to be another member of this same family.

At the time of discovery the comet was not so bright as Comet *b*, its brightness being estimated at about 10 or a little fainter. It has been steadily increasing in brightness and is now estimated to be 9 or 9½ magnitude, brighter than Comet *b*. A rather sharp nucleus has developed within the past week and is now estimated to be about 13th magnitude.

Comet *e* has been moving in the same general direction as Comet *b*, and as its geocentric motion has been much more rapid it has overtaken the latter and passed it in both co-ordinates. On the morning of June 27th, the two comets were within about one-quarter degree of each other, both visible in the lowest power field of the 12-inch telescope.

Comet *e* is moving rapidly south and east, and hence its location is becoming more unfavorable for observation. Towards the middle of August it will pass the Sun going south, after which it will soon be lost to northern observers. Owing to the resemblance already pointed out, it seems important to observe it as long as possible. C. D. PERRINE.

MT. HAMILTON, Cal., 1898, June 29.

ERRATA IN STAR CATALOGUES.

Lalande 31379. The declination of this star appears to be in error by 1′. A micrometer comparison with *Radcliffe*$_{3'}$ 4514 on June 2d indicates that the N. P. D. of *Lalande* 31379 should be $100^\circ\ 25'\ 39''.8$.

WEISSE'S *Bessel XVIII*, 1327 appears to be in error in declination by 2′. A micrometer comparison with 1323 on June 2d shows that the declination of 1327 should be $-13^\circ\ 44'\ 10''.5$.

C. D. PERRINE.

MT. HAMILTON, Cal., June 7, 1898.

Two Bright Meteors, June 24 and June 29, 1898.

On the morning of June 24, at $1^h\ 17^m\ 53^s$ P. S. T., a very brilliant meteor was seen to pass southeast through the constellations *Cassiopeia* and *Perseus*, bursting a little southwest of the star γ *Persei*. This meteor was a brilliant bluish-white, and fully ten times as bright as *Venus* at the present time.

At $8^h\ 16^m\ 26^s$ P. S. T., in the evening of June 29th, while it was yet very bright twilight, an unusually large meteor was seen in the southwest. When first seen it was at an altitude of about 20° above the horizon. It passed slowly toward the west, making a small angle with the horizontal, disappearing almost due west and but little above the horizon. A few seconds after it was first noticed several fragments were thrown off—the main body being diminished but little in brightness, however, and continuing in the same course.

It was of the usual brilliant bluish-white type, and fully twenty to thirty times as bright as *Venus*, which was visible in the northwest. The meteor was seen for eight seconds—the time given being that of disappearance. C. D. Perrine.

Mt. Hamilton, Cal., 1898, June 30.

Comet *c* 1898 (Coddington).

A letter, dated June 16, 1898, received from Harvard College Observatory, states that photographs of Comet Coddington were obtained at the Harvard College Observatory by Mr. King on June 14 and 15, 1898. A measurement by Mr. Wendell of the light of the nucleus of this comet showed that its intrinsic brightness was equal to that of a star of magnitude 7.7 when spread over a circle one minute of arc in diameter.

The following letter, dated June 18, 1898, has also been received: "A telegram has been received at Harvard College Observatory from Professor Kreutz, at Kiel Observatory, stating that the following elements and ephemeris* of Comet *c* 1898 were computed by Berberich:—

$$
\begin{aligned}
T &= 1898,\ \text{August } 4.44 \text{ G. M. T.} \\
\omega &= 206^\circ\ 09' \\
\Omega &= \ \ 73\ \ 59 \\
i &= \ \ 76\ \ 48 \\
q &= \ \ 2.0821 \text{ ''}
\end{aligned}
$$

*The ephemeris is here omitted.

ELEMENTS OF COMET *e* 1898 (PERRINE).

From the Mt. Hamilton observations of June 14, 15 and 16, we have computed the following elements of Comet *e*, 1898:—

$$\begin{aligned} T &= 1898, \text{ August } 17.400. \\ \omega &= 196^\circ\ 45'\ 48'' \\ \Omega &= 260\quad 5\quad 55 \\ i &= \ \ 69\quad 42\quad 23 \\ \log q &= 9.87026 \end{aligned} \left.\vphantom{\begin{aligned}\omega\\ \Omega\\ i\end{aligned}}\right\} \text{Ecliptic and Mean Equinox of 1898.0}$$

Residuals for the middle place, (O—C):

$\Delta\lambda = +2''$, $\Delta\beta = -5''$.

C. D. PERRINE and R. G. AITKEN.

ELEMENTS OF COMET 1898 *g* (GIACOBINI).

This comet was discovered by Mr. GIACOBINI, of the Nice Observatory, June 18th. From the Nice observation of June 19th, and my observations of June 23d and 27th, I have computed the following elements of the orbit:—

$$\begin{aligned} T &= 1898 \text{ July } 25.84828 \text{ G. M. T.} \\ \omega &= \ \ 22^\circ\ 41'\ 26''.5 \\ \Omega &= 278\quad 17\quad 30\ .3 \\ i &= 166\quad 50\quad 58\ .1 \\ \log q &= 0.175956 \end{aligned} \left.\vphantom{\begin{aligned}\omega\\ \Omega\\ i\end{aligned}}\right\} \text{Ecliptic and Mean Equinox of 1898.0}$$

(O—C): $\Delta\lambda' \cos\beta' = -1''.8$; $\Delta\beta' = +2''.1$

The comet is telescopic. When discovered it had a stellar nucleus of about the 9th magnitude and scarcely a trace of a tail. It was then near opposition, and consequently its tail was very unfavorably situated for observation. The comet has been diminishing in brightness; it has also been moving rapidly westward, and by the end of the present month it will be reaching a position unfavorable for observation.

On the evening of July 14th, I examined the comet with the 36-inch refractor and found the nucleus small, stellar in appearance, and not brighter than a star of the 11th magnitude. The coma was some 30″ or 40″ in diameter and a well-developed tail, some 5′ or 6′ in length, was visible. The tail was narrow, tolerably bright near the nucleus, but becoming rapidly fainter as the distance from the nucleus increased. W. J. HUSSEY.

July 18, 1898.

ELEMENTS OF COMET *e* 1898 (PERRINE).

From my observations of this comet on June 17th and 24th and July 1st, I have computed the following system of parabolic elements:—

$$T = 1898, \text{ August } 16.23874 \text{ G. M. T.}$$

$$\left.\begin{array}{rl} \omega = & 205^\circ\ 12'\ 18''.2 \\ \Omega = & 259\ \ 10\ \ 16\ .4 \\ i = & 70\ \ \ 0\ \ 10\ .8 \end{array}\right\} \text{Ecliptic and Mean Equinox of 1898.0}$$

$$\log q = 9.800186$$

Residuals for the middle place are—

$$O - C: \Delta\lambda' \cos \beta' = -2''.5; \quad \Delta\beta' \cos \beta' = +4''.0$$

These elements do not differ materially from the first set obtained. The comet has grown much brighter, has increased in size, and now has a short brush of a tail, extending away from the Sun. A nucleus has developed, and is at present fully as bright as a tenth-magnitude star. The entire comet is about equal in brightness to an eighth-magnitude star.

Its rapid motion south and east will soon cause it to be lost in the Sun's rays. It should become visible to observers in the southern hemisphere towards the end of August, and should be even brighter then than now. C. D. PERRINE.

MT. HAMILTON, California, July 26, 1898.

FELLOWSHIPS AT THE LICK OBSERVATORY.

Messrs. RUSSELL T. CRAWFORD, FRANK E. ROSS, and HAROLD K. PALMER, all graduates of the University of California, have been appointed to Fellowships in Astronomy at the Lick Observatory for one year, beginning on the 1st of August, 1898. Mr. E. F. CODDINGTON has also been reappointed Fellow in Astronomy.

THE LARGE REFRACTORS OF THE WORLD.

The following list of large telescopes has been taken from the list published in *The Observatory* for June, 1898, which includes all refractors having aperture of 13.4 inches or over. One or two corrections have been made in the third column.

The fourth column gives the name of the maker of the object-glass; when it is known that the mounting was made by a second firm, a number is affixed, signifying respectively: (1) WARNER & SWASEY; (2) GAUTIER; (3) REPSOLD; (4) RANSOME and SIMMS; (5) SAEGMÜLLER.

Aperture in Inches.	Focal length in feet.	Institution.	Maker.	Date of Erection.	Remarks.
40.0	62.0	Yerkes Observatory, Wisconsin	Alvan Clark (1)	1897	Visual.
36.0	57.8	Lick Observatory, California	Alvan Clark (1)	1888	Visual.
33.0	49.2	Lick Observatory, California	Alvan Clark (1)	....	Photographic corrector to 36 in.
32.5	53.0	National Observatory, Meudon	Henry Bros. (2)	1891	Visual.
31.1	39.4	Astrophysical Observatory, Potsdam	....	....	Photographic. Not erected.
30.3	52.6	Bischoffsheim Observatory, Nice	Henry Bros. (2)	1889	Visual.
30.0	42.0	Imperial Observatory, Poulkova	Alvan Clark (3)	1882	Visual.
28.9	....	National Observatory, Paris	Martin	....	
28.0	28.0	Royal Observatory, Greenwich	Sir H. Grubb (4)	1894	Visual and photographic.
27.0	34.0	Imperial Observatory, Vienna	Sir H. Grubb	1878	Visual.
26.0	26.0	Royal Observatory, Greenwich	Sir H. Grubb	1897	Photographic.
26.0	32.5	Naval Observatory, Washington, D. C.	Alvan Clark (1)	1871	Visual.
26.0	32.5	Leander McCormick Observatory, Virginia	Alvan Clark	1874	Visual.
25.0	....	Cambridge (Eng.) University Observatory	T. Cooke & Sons	1868	Visual.
24.4	52.2	National Observatory, Meudon	Henry Bros. (2)	1891	Photographic.
24.0	11.3	Harvard College Observatory	Alvan Clark	1894	Photographic doublet.
24.0	22.6	Royal Observatory, Cape of Good Hope	Sir H. Grubb	1897	Photographic.
24.0	31.0	Lowell Observatory, Arizona	Alvan Clark	1895	Visual.
23.6	59.0	National Observatory, Paris	Henry Bros. (2)	1889	Visual } These two telescopes on the same mounting form the Equatorial Coudé.
23.6	59.0	National Observatory, Paris	Henry Bros. (2)	1889	Photographic
23.0	32.0	Halsted Observatory, Princeton	Alvan Clark	1881	Visual.
21.8	....	Etna	Merz	....	
21.2	....	Buckingham Observatory	Buckingham & Wragge	....	
20.5	....	M. Porro, Private Observatory, Italy	M. Porro	....	
20.0	28.0	Chamberlin Observatory, Colorado	Alvan Clark (5)	1891	Visual.
20.0	....	Manila Observatory, Philippine Islands	Merz	1892	
19.7	41.2	Astrophysical Observatory, Potsdam	....	....	Guiding telescope for the 31.3 in.
19.1	23.0	Imperial Observatory, Strassburg	Merz (3)	1880	Visual.
19.1	23.0	Milan Observatory, Italy	Merz (3)	....	Visual.
18.5	27.0	Dearborn Observatory, Evanston	Alvan Clark	1863	Visual.
18.1	29.5	National Observatory, La Plata	Henry Bros. (2)	1890	Visual. Coudé.
18.0	26.3	Lowell Observatory, Arizona	Alvan Clark	1894	Visual.
18.0	....	Flower Observatory, Philadelphia	Brashear (1)	1896	Visual.
18.0	....	Van Duzee Observatory	Fritz	....	
18.0	22.6	Royal Observatory, Cape of Good Hope	Sir H. Grubb	1897	Visual.

ASTRONOMICAL TELEGRAMS (*Translation*).

Lick Observatory, June 12, 1898.

To Harvard College Observatory:
To Students' Observatory, Berkeley: (Sent 10:10 A. M.)

A bright comet was discovered by E. F. CODDINGTON by photography. It was observed by W. J. HUSSEY, June 11.7220 G. M. T.; R. A. $16^h\ 24^m\ 45^s.9$; Decl. $-25^\circ\ 14'\ 20''$.

The daily motion of the comet is $+51'$ in R. A. and $-36'$ in Decl.

Lick Observatory, June 13, 1898.

To Harvard College Observatory:
To Students' Observatory, Berkeley: (Sent $9^h\ 55^m$ A. M.)

Comet *c* 1898 (CODDINGTON) was observed by E. F. CODDINGTON, June 12.7288 G. M. T.; R. A. $16^h\ 21^m\ 34^s.1$; Decl. $-25^\circ\ 52'\ 43''$.

Lick Observatory, June 14, 1898.

To Harvard College Observatory:
To Students' Observatory, Berkeley: (Sent $8^h\ 30^m$ A. M.)

Comet *c* 1898 (CODDINGTON) was observed by E. F. CODDINGTON, June 13.7583 G. M. T.; R. A. $16^h\ 18^m\ 5^s.0$; Decl. $-26^\circ\ 31'\ 48''$.

BOSTON, Mass., June 14, 1898.

To Lick Observatory: (Received $1^h\ 10^m$ P. M.)

ENCKE'S periodic comet has been observed on its return by TEBBUTT, at Windsor. Its position on June 11.8435 G. M. T. was R. A. $6^h\ 53^m\ 29^s.0$; Decl. $+11^\circ\ 34'\ 00''$.

(Signed) JOHN RITCHIE, Jr.

Lick Observatory, June 15, 1898.

To Harvard College Observatory:
To Students' Observatory, Berkeley: (Sent $3^h\ 25^m$ P. M.)

Comet *c* 1898 (CODDINGTON) was observed by R. H. TUCKER with the Meridian Circle, June 13.7876 G. M. T.; R. A. $16^h\ 17^m\ 58^s.4$; Decl. $-26^\circ\ 33'\ 3''$.

Lick Observatory, June 15, 1898.

To Harvard College Observatory:
To Students' Observatory, Berkeley: (Sent $10^h\ 05^m$ P. M.)

A faint comet was discovered by C. D. PERRINE on June 14.974 G. M. T. in R. A. $3^h\ 29^m$; Decl. $+58^\circ\ 36'$. Its daily motion is $+1^\circ\ 34'$ in R. A. and $+12'$ in Decl.

Lick Observatory, June 16, 1898.

To Harvard College Observatory:
To Students' Observatory, Berkeley: (Sent 11^h 22^m A. M.)

Comet *e* 1898 (PERRINE) was observed by C. D. PERRINE, June 14.9740 G. M. T.; R. A. 3^h 29^m $1^s.0$; Decl. + 58° 35′ 25″; and June 15.9296 G. M. T.; R. A. 3^h 34^m $57^s.7$; Decl. 58° 24′ 2″.

Lick Observatory, June 17, 1898.

To Harvard College Observatory:
To Students' Observatory, Berkeley: (Sent 10^h 40^m A. M.)

Comet *e* 1898 was observed by C. D. PERRINE, June 16.9376 G. M. T.; R. A. 3^h 41^m $11^s.9$; Decl. + 58° 10′ 49″.

Lick Observatory, June 17, 1898.

To Harvard College Observatory: (Sent 10^h 40^m A. M.)

WOLF'S periodic comet has been observed on its return by W. J. HUSSEY, June 16.9666 G. M. T.; R. A. 2^h 16^m $18^s.9$; Decl. + 19° 42′ 44″.

Lick Observatory, June 17, 1898.

To Harvard College Observatory: (Sent 3^h 35^m P. M.)

Elements and ephemeris* of Comet *e* 1898 (PERRINE) were computed by C. D. PERRINE andR . G. AITKEN as follows:

$$T = 1898, \text{ August } 17.400 \text{ G. M. T.}$$

$$\left.\begin{aligned} \omega &= 196^\circ\ 46' \\ \Omega &= 260\ \ 06 \\ i &= 69\ \ 42 \end{aligned}\right\} \begin{array}{c}\text{Ecliptic and} \\ \text{Mean Equinox of 1898.0}\end{array}$$

$$q = 0.7418$$

Lick Observatory, June 18, 1898.

To Harvard College Observatory: (Sent 10:20 A.M.)

Elements and ephemeris† of Comet *c*, 1898 (CODDINGTON) were computed by W. J. HUSSEY and E. F. CODDINGTON as follows:—

$$T = 1898, \text{ September } 10{:}31 \text{ G. M. T.}$$

$$\left.\begin{aligned} \omega &= 229^\circ\ 28' \\ \Omega &= 73\ \ 59 \\ i &= 71\ \ 18 \end{aligned}\right\} \begin{array}{c}\text{Ecliptic and} \\ \text{Mean Equinox of 1898.0}\end{array}$$

$$q = 1.7685$$

* The ephemeris is here omitted.

† The ephemeris is here omitted.

BOSTON, Mass., June 21, 1898.

To Lick Observatory: (Received 4:30 P. M.)

Comet *g* 1898 (GIACOBINI) was observed at Nice, June 19.5079 G. M. T.; R. A. $20^h\ 26^m\ 40^s.8$; Decl. $-21^\circ\ 27'\ 6''$. The daily motion is $-2^\circ\ 52'$ in R. A. and $-20'$ in Decl.

(Signed) JOHN RITCHIE, Jr.

BOSTON, Mass., June 27, 1898.

To Lick Observatory: (Received 9:00 P. M.)

Elements and ephemeris* of Comet *g* 1898 (GIACOBINI) were computed by Professor KREUTZ as follows:—

$$T = 1898,\ \text{July } 6.23\ \text{G. M. T.}$$

$$\left.\begin{aligned} \omega &= \ \ 7^\circ\ 36' \\ \Omega &= 278\ \ \ 31 \\ i &= 166\ \ \ 45 \end{aligned}\right\} \begin{array}{c}\text{Ecliptic and} \\ \text{Mean Equinox of 1898.0}\end{array}$$

$$q = 1.5864$$

This is a rough approximation.

(Signed) JOHN RITCHIE, Jr.

INDEPENDENT DISCOVERY OF COMET *c* 1898.

From a note in the *Astronomische Nachrichten*, No. 3500, it appears that Comet *c* 1898 (CODDINGTON), discovered at the Lick Observatory on June 11th, was discovered independently in Bukarest, on June 14th, by Mr. W. PAULY. Clouds interfered before he was certain of the cometary nature of the object; and it was not until June 16th that he telegraphed his discovery to the Central Stelle, at Kiel. As Mr. PAULY does not receive the astronomical telegrams distributed from Kiel, he was not aware that his discovery had been anticipated, though the comet was observed at various European observatories on June 13th and 14th.

CONFERENCE OF ASTRONOMERS AND PHYSICISTS.

The conference of astronomers and physicists held at the dedication of the Yerkes Observatory in October, 1897, was so successful that it has been decided to hold a second meeting this year, the meeting-place to be the Harvard College Observatory. The days of meeting are Thursday, Friday, and Saturday, August 18th, 19th, and 20th, 1898. These days were selected in order that visiting astronomers might attend the meeting of

* The ephemeris is here omitted.

the American Association for the Advancement of Science which will be held in Boston during the week beginning Monday, August 22d.

According to Professor E. C. PICKERING'S circular letter, it is expected that numerous short papers will be presented informally, illustrated, when desired, by lantern slides, and fully discussed. The work of the various departments of the Harvard College Observatory will be shown, and excursions will be planned to various neighboring scientific institutions.

OBITUARY NOTICE.*

WILLIAM AUGUSTUS ROGERS, Professor of Physics and Astronomy in Colby University, Waterville, Maine, died at that place on March 1, 1898, after an illness of several weeks, brought on by a severe fall.

He was born at Waterford, Connecticut, on November 13, 1832, and graduated at Brown University in 1857. Soon afterwards he became Professor of Mathematics and Astronomy at Alfred University, in the State of New York. During his tenure of this office, he passed some time at the Observatory of Harvard College, and took part in its work under the direction of Professor BOND; and he was subsequently engaged for fourteen months in the naval service of the United States during the Civil War, which broke out in 1861. In 1870, after much success at Alfred University, both as a teacher and as an investigator, he returned to Harvard College Observatory, under the direction of Professor WINLOCK, and was soon placed in exclusive charge of the new meridian circle mounted in that year. With this instrument he undertook the observation of the zone from 49° 50′ to 55° 10′ north declination, as a part of the general revision of the *Durchmusterung*, proposed by the *Astronomische Gesellschaft*. The results of this work are published in Vols. XV, XVI, XXV, XXXV and XXXVI of the *Annals* of the Astronomical Observatory of Harvard College. Volumes X and XII of the same series contain the results of observations made in connection with the zone observations upon a selected list of stars in various declinations. Professor ROGERS also made a series of observations for determining the absolute positions of certain stars, the reduction of which he did not live to complete; but it is hoped that it can be finished in accordance with his intentions.

* From *Astronomische Nachrichten*, No. 3499.

In making transit observations, Professor ROGERS preferred to use double lines etched or ruled upon glass plates instead of spider lines. The experiments which he undertook in preparing such plates led him by degrees to elaborate investigations in the exact measurement of standards of length. He carried on these researches with great energy and perseverance, at the same time with his astronomical work, and with unusual success. It would be impracticable in the present notice to give even a brief account of this section of his labors, the results of which are, however, well known and appreciated among physicists.

He was appointed Assistant Professor of Astronomy at the Observatory in 1877, and held that office till 1886, when he resigned it to accept the professorship at Colby University, where he spent the remainder of his life in the same active and zealous devotion to scientific pursuits by which he had always been distinguished. While continuing to superintend the reduction of the observations which he had made at Cambridge, he also found time, not only for teaching, but for the pursuit of many physical investigations. Among others may be mentioned the study of the so-called X-rays, in which he engaged with an ardor which may perhaps have contributed to enfeeble his naturally vigorous constitution.

Numerous contributions to scientific periodicals and to the proceedings of the learned societies of which he was a member, as well as the larger publications already mentioned, remain to attest his industry and capacity as a man of science, while the remembrance of his high character and cordial manners will long be cherished by those who knew him.

ARTHUR SEARLE.

HARVARD COLLEGE OBSERVATORY, May 6, 1898.

OFFICERS OF THE SOCIETY.

OFFICERS OF THE CHICAGO SECTION.

OFFICERS OF THE MEXICAN SECTION.

NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book-keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the *Publications* for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of two dollars per volume to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to the Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the card.

The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States. The responsibility for the views expressed in the papers printed rests with the writers, and is not assumed by the Society itself.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery, stamped with the seal of the Society, at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific" at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.

PUBLICATIONS ISSUED BI-MONTHLY.

(February, April, June, August, October, December.)

PUBLICATIONS

OF THE

Astronomical Society of the Pacific.

VOL. IX. SAN FRANCISCO, OCTOBER 1, 1898. NO. 64.

THE TEMPERATURE OF THE SUN. I.

BY PROF. DR. J. SCHEINER.

[Translated from the German in *Himmel und Erde*, by FREDERICK H. SEARES.]

The problem of determining the temperature of the Sun appears at first glance to be quite insolvable. It is well known that difficulties, scarcely to be overcome, oppose the attempts to determine accurate values for the high temperatures occurring in laboratory work and in technology; while for the highest temperatures which can be produced on the Earth, the problem has in no way been solved with satisfactory accuracy. How much greater, therefore, must be the difficulties when we attempt to determine the temperature of a body separated from us by nearly 100,000,000 miles, and which in consequence cannot be handled and manipulated as the burning or glowing object in the laboratory. In truth, the difficulties confronting the investigator are great, and so far they have in part proved insurmountable.

But when have the mere difficulties of a problem prevented men from attempting a solution? On the contrary, they have proved an allurement; for the satisfaction incident upon the successful solution of a problem increases with the expenditure of energy necessary to obtain the result; and with the great multitude the profit to be expected in fame and honor, and eventually in power and wealth, is a sufficient inducement.

In the extraordinarily numerous attempts to determine the solar temperature this last incitement has not been present; for the result can have only a purely scientific, or at the most, a general

The temperature scale used in this article is the Centigrade.—*Translator.*

interest for mankind — never such an interest as is aroused by the opening of new lines in technology, or by the introduction of new industrial methods.

In the earliest times it was recognized that man owed his very existence to the Sun, the dispenser of light and heat. This dependence has been acknowledged in various ways: by the universal division of time into days and years according to the motion of the Sun, a custom dating from the remotest antiquity; by his introduction as the source of life into the mythologies of many peoples; and even at the present day by his presence as the central idea in the religion of the Sun Worshipers.

In astronomical science the Sun was considered for centuries as a burning heavenly body, burning as a piece of wood burns in our own atmosphere; but at the beginning of the present century this idea fell into disrepute through the influence of HERSCHEL, who assumed the Sun itself to be a dark body surrounded by an intensely luminous and radiant atmospheric shell. In apparent agreement with this theory was the evidence afforded by sun-spots, whose dark centers were thought to be layers of clouds seen through openings in the photosphere protecting the solar surface from the intense radiation of the atmosphere above. With a means of protection from heat thus provided, it was characteristic of the thought of the time to fancy the Sun inhabitable. The living being able to recognize the all-ruling God, and therefore in a position to attain the highest goal of nature, was, according to that thought, the crown of creation, and an uninhabitable world was therefore without reason. To-day such speculations are without influence for the majority of investigators. We admire no longer the harmonious ordering of the universe without recognizing the existing arrangement as only one of an infinitely great number of possible arrangements — *the* one which best conforms to the conditions of nature, or which can best adjust itself to them.

Another idea in harmony with HERSCHEL'S theory was that the shining envelope of the Sun did not possess an especially high temperature, that it merely shone, and that heat was generated only when the rays fell upon some body.

In the middle of the century two great revolutionary discoveries were made which dispatched with a single blow all such ideas.

They were the law of conservation of energy with the related mechanical theory of heat, and the principles of spectrum analysis.

It would lead too far to explain these in detail here, and merely the final results in their relation to the solar constitution as accepted by the majority of scientists will be given, with the risk that such a procedure will be unsatisfactory to many.

We are to imagine the Sun as an enormous glowing ball of gas, whose temperature diminishes from the center outward. At a certain depth, and in consequence of causes analogous to those acting in our own atmosphere, a part of one or more of the glowing gases is condensed into cloudlike forms. The layer containing these is called the photosphere; it is the region from which the bulk of the heat and light are emitted, and forms at the same time the visible sharp outline of the Sun. With this idea of the solar constitution it appears that properly one cannot speak of a temperature of the Sun, since for different parts the temperature is quite different; and if from the solar radiation we determine a temperature, it must refer to the point of emission, namely, the photosphere. Our problem is therefore limited to the determination of the temperature of the photosphere. Here we meet difficulties at once; for in the study of radiation the constitution of the radiating body is by no means immaterial. This has been shown in a previous article in this periodical (*Himmel und Erde*, Bd. IX, Heft 6) in connection with the subject of emission, and may be assumed for the present purpose. There need be remembered only the instance where particles of glass and metal were subjected to the same temperature. Although the two substances were of the same temperature, the glass radiated but little heat and light as compared with the metal, or as it may be stated, the luminous power of the glass was far less than that of the metal. Since the emissive power of the particles of the photosphere is unknown, it is necessary to make an assumption as to its value, if we are to determine the temperature of the photosphere from the intensity of its radiation. The simplest assumption for this value is unity — *i. e.* equal to the emissive power of an absolutely black body. It is commonly known that upon this assumption we obtain the minimum value for the solar temperature. If the emissive power is less than 1, the temperature is higher. In what follows it is to be understood that the term solar temperature refers to that temperature which the photosphere would have in case its emissive power were unity. This does not remove all of the difficulties, however.

According to our assumptions the photosphere consists not

of a solid body, but of a layer of gas in which solid particles are suspended. This layer itself can scarcely possess a uniform temperature; the inner portions must be much hotter than the outer. Further, the inner portions emit radiation, which in its passage through the outer layers is only partially absorbed, and therefore we cannot speak of a definite temperature as belonging to the photosphere, but only of an average temperature which may be defined as the sum of the radiation effects from all parts of the photospheric layer. But with such a constitution there enters a variation in the emissive power. That quantity for the whole photosphere depends upon two factors, namely, the number of solid particles per unit area in the photosphere, and the absorbing power of the overlying layers of gas. If the emissive power of the particles themselves be unity, that of the photosphere, as a whole, will always be less than unity. The greater the number of particles, the greater will be the emissive power; but by increasing the number of particles the emissive power can be made 1 only when the absorptive power of the outer layers is infinitesimal.

It is not easy to see to what extent these factors are operative; it results, however, that the assumption, emissive power = 1, is not accurate, but that the value is too large.

From the observation of solar radiation, therefore, we can solve only the following: *To determine the temperature of an absolutely black body having the same apparent diameter as the Sun, and the same radiation effects.*

We are now in a position to understand what will be meant in future by temperature of the Sun. There are already considerable difficulties to be encountered in the solution of the problem, and they will increase quite extraordinarily as the solution progresses.

It must now be asssumed that we are able with appropriate apparatus to determine with accuracy the intensity of solar radiation. In fact, this determination must be made at the bottom of our atmosphere, in which the rays have lost a portion of their energy by absorption. That this loss is not inconsiderable is a matter of common experience. The rising and setting Sun, for example, exercise but slight heating effect on account of the great absorption taking place in the long path through the atmosphere which the rays must traverse.

We must then determine the exact diminution in the energy

of radiation corresponding to a given altitude of the Sun. With the theoretical part of this determination we cannot here concern ourselves; it is closely related to the theory of refraction in our atmosphere, and its comprehension presupposes a knowledge of mathematics not to be expected of the general reader. Such an understanding is unnecessary, for in practice we can do without the theory of extinction. We need only apparatus for measuring the intensity of solar radiation for all altitudes of the Sun from horizon to zenith. The values thus obtained for the loss by absorption can be plotted as ordinates on co-ordinate paper, with the corresponding altitudes as abscissæ, and a curve can be drawn through the plotted points. If for a later observation the loss by absorption for a certain altitude is desired, it can be read from the curve. A graphical method of this sort leads to the same results as those obtained by theory combined with observations, but even this simple procedure becomes exceedingly complicated on account of the variable absorptive power of air. At the outset the absorptive power varies with the barometric height, but since absorption depends upon the number of particles encountered by the ray, it is possible to consider the absorptive power proportional to the barometric height, which leads to a simple reduction. In a similar manner the altitude of the observer above sea-level can be taken into account. But far more uncertain is the dependence of absorption upon water vapor, the amount of which in the atmosphere is subject to sudden and extreme variations. It cannot be taken into account with accuracy since its value can be determined only for points near the surface of the earth, and not for the upper layers through which the solar rays must also pass. Again, the effect of the light cloudlike formations of the upper atmosphere, recognized by their whitish appearance on the blue sky, is uncertain, and cannot be allowed for numerically. Thus the actual absorption for each day, oftentimes for each hour, is different, and inasmuch as only mean values can be found, important errors enter into individual determinations whose effect can be eliminated, in a measure, only by the use of a great number of observations.

At the present day it is possible to determine the effect of absorption accurately to within, perhaps, ten per cent. of its true value, so that the corrected radiation values corresponding to the true solar radiation without an atmosphere are accurate, so far as they are affected by this one uncertainty, to a proportional amount.

We have proceeded so far as to get values for the solar radiation unaffected by our atmosphere, and we now come to a description of one of the most important points of the whole problem, the measurement of the radiation. At first sight this does not appear difficult; *e. g.* a thermometer which has been in the shade can be read and then exposed to the solar radiation; the column of mercury immediately rises and comes to rest 12° to 14° higher up. Radiation has increased the reading by this amount, and from this data we can determine a value for the amount of radiation, but the value would be only approximate at best; it may be in error one hundred per cent., or more.

It is an inviolable physical law that every body radiates heat in all directions, the amount of which depends only on the temperature of the radiating body, and not upon the temperature of those surrounding it. The higher the temperature, the greater is the amount of radiation. The same law holds equally for the surrounding bodies, and it thereby follows that a body of a temperature higher than its neighbors must lose heat, while those of a lower temperature must gain. The tendency is to set up a uniformity of temperature throughout all the bodies in question. It may be remarked incidentally that this is the condition toward which the whole universe tends — to an equality of temperature for all bodies and parts of bodies, be they large or small. The outlook for the future is a dismal one; for ultimately every source of energy, whether it lie in animate or in inanimate material, must become exhausted. We may console ourselves with the thought that an infinitely long time will be required for this condition of things to come about.

If now we subject a thermometer to solar radiation, and find, after a time, that the column of mercury comes to rest in a higher position than in shadow, it can be said that from this moment on, the radiation of the thermometer is equal to the energy received from the surrounding objects, not merely from the Sun, but also from the ground, from the clouds, from buildings, etc. The slightest variation in the position of the instrument changes its distance from some of the radiating bodies, and consequently the indicated temperature. Even the radiation from the screen used to protect the thermometer in determining the difference between shade and sunlight modifies the result.

The observations must be made in open air; for the introduction of glass into the path of the rays would seriously affect the

result. But here air-currents, even the lightest puff, prove disturbing sources of error, since, in general, they are of a different temperature from the thermometer, and either give up or take away heat.

Besides these external sources of error, there is a whole series of internal ones, depending upon, and varying with, the construction of the apparatus used. It is, therefore, not surprising that the accurate measurement of radiation of the Sun is far from a satisfactory solution—satisfactory to the scientist who desires to obtain in his investigations the highest possible degree of accuracy. If in the measurement of solar radiation we are satisfied to accept an accuracy of twenty per cent., as will be done in what follows, in order to gain some insight into the matter, the problem may be considered as solved. Instruments designed for the measurement of solar radiation are collected together under the name of actinometers, of which certain forms are called pyrheliometers. These instruments are best classified according to whether they are arranged to give absolute or relative measurements of the energy of radiation.

With the latter sort is to be included the simple thermometer, alternately exposed to light and shadow, and also thermo-electric apparatus, the bolometer, etc., whose purpose is understood without further explanation, since they give only differences of temperature. Instruments of the first sort, for our purpose, are of greater importance. They indicate not how much the temperature of a body is increased by solar radiation, but how much heat is conducted to the apparatus by the radiation; they serve to measure the energy of the solar radiation. The temperature degree is a measure of the intensity of the heat; while for the energy a much more complicated unit must be introduced, namely, the calorie, by which we mean the amount of heat which must be applied to one gram of water at 0°, in order to raise its temperature to 1°. Ten calories, therefore, can be used in an infinite number of ways; *e. g.* 1 gram of water can be raised to 10°, or 10 grams of water to 1°, or 5 grams of water to 2°, etc. Water is chosen as a standard, each substance requiring a relatively different amount of heat to produce a given temperature effect. Much less heat is required to raise a gram of iron 1° than a gram of water, and the number expressing the ratio of the amounts of heat required to produce the same increase in temperature in the same amounts of water and a given substance is

called the specific heat of the substance. For example, the specific heat of iron is 0.11, which means that, to raise 1 gram of iron 1°, 0.11 calories is required.

The determination of the number of calories alone is not sufficient for the determination of the heat conducted by radiation; for the amount received increases with the time during which the radiation acts, and with the increase of the surface exposed to the rays.

The energy of radiation is therefore expressed in calories, referred to 1 square centimeter of surface and to a duration of radiation of one minute. Every actinometer must have as an essential part a surface which is exposed to the radiation, and whose area and specific heat are accurately known. It is very important that the surface should absorb as much as possible of the radiation, which means that it must be rough and black; a polished silver mirror, for example, is scarcely affected by the solar rays.

The first to concern himself with this problem was POUILLET, who made his experiments in 1838. The pyrheliometer used by him was of the following construction:—

One end of a flat cylindrical vessel of sheet-silver was blackened with soot, and placed so that the solar rays fell perpendicularly upon it. The vessel was filled with about 100 grams of water, whose increase in temperature was measured by a thermometer projecting into the vessel. During the observation the vessel was rotated about its axis, in order that the contents might become of the same temperature throughout. Many later observers have retained POUILLET'S method in its essentials, and have introduced only slight modifications; for example, CROVA used mercury instead of water.

Of an entirely different construction was the actinometer of VIOLLE. The surface exposed to radiation was small, and was protected from wind and the radiation of surrounding objects by a complete covering of constant temperature. The blackened bulb of a thermometer served as the surface, and it was placed in the center of a large double-walled sphere, which was kept at a constant temperature by flowing water. The exposure of the thermometer bulb to radiation was made possible by a tube passing from the center outward, which contained a diaphragm of the same diameter as the thermometer bulb. When the tube was directed toward the Sun, the bulb lay in the path of the rays.

As a third fundamental type of actinometer, we may consider

that of ÅNGSTRÖM. It consisted essentially of two equal copper discs, blackened upon one side and exposed to the Sun. In the centers of the unexposed surfaces of these discs were attached thermo-elements, which connected with a galvanometer gave accurately the temperature of the discs. The two discs were alternately exposed to the radiation and their differences of temperature measured. An especial advantage of this apparatus (constructed in 1887) over the others is its symmetrical arrangement, by means of which several external sources of error are excluded.

It may be further stated, that with none of these apparatus is it necessary to allow the radiation to act until no further increase of temperature is perceptible. With short intervals of alternation between light and shade, it is possible to deduce the desired quantities from appropriate formulæ.

There is yet a whole series of actinometers which have been used, but they can all be referred to one of the three types above, and do not need further explanation. On the contrary, of especial interest are the *numbers* which have been obtained for the energy of radiation of the Sun by means of these various instruments. Arranged chronologically, they show a decided increase, corresponding to the development of apparatus and methods of observation.

OBSERVER.	YEAR.	CALORIES.
POUILLET	1838	1.76
FORBES	1842	1.82
HAGEN	1860	1.9
VIOLLE	1875	2.54
CROVA	1878	2.3
LANGLEY	1884	3.07
SAVELIEF	1880–1890	3.47
PERNTER	1880–1890	3.28
ÅNGSTRÖM	1894	4.0

From this series of values, there appears to be no question but that the true value of the energy of solar radiation, or the so-called solar constant, lies between 3.5 and 4.0 calories, and that we may take, as the most probable value, 3.75, which it will be noticed, is about double the first determinations.

At the end of this article, several interesting computations will be carried through with the aid of this constant, but we will now proceed with the main problem.

With a variation of only fifty per cent. in the determinations of solar radiation, a similar variation in the deduced values of the solar temperature might be expected. This is not the case, however; the determinations of this temperature differ from each other so enormously, that in consequence the results have long since been viewed with a certain contempt. For example, it may be noted that POUILLET deduced the round number 1,500° for the solar temperature, while SECCHI, early in 1870, with a similar apparatus, found the value 10,000,000°.

Wherein, then, do these inconceivable differences enter? The answer to this question leads us at once to the most difficult, and at the same time the most interesting, part of our problem. It is required to determine from relatively small differences of temperature the value of an extremely high temperature, and naturally any error in the temperature difference appears enormously multiplied in the result. Let us begin, for example, with an error of 1° in a temperature difference of 10°; if the true result should be 10,000°, it will appear, in consequence of the error, increased by 1,000°. This, however, in itself is insufficient to explain the great discrepancies which occur; a much more uncertain source of error arises from a lack of knowledge concerning the law of radiation — the law connecting the temperature of the radiating body with the energy of the radiation emitted. A law of this sort can be deduced from observations in the laboratory. A sheet of platinum, for example, can be heated to a temperature of 1,000°, and then its radiation can be studied. But aside from the great practical difficulties which oppose such investigations, there is the unfortunate circumstance that the temperature of the Sun is doubtless far higher than any temperature which can be produced for measurement in the laboratory; from the relation between radiation and temperature from 0° to 1,000° must be inferred the relation for temperatures from 1,000° to 10,000°.

If the relation between temperature and radiation be plotted as a curve, with temperatures as abscissæ, that part of the curve between 0° and 1,000° can be accurately determined by observation. The course of the nine-tenths of the curve beyond 1,000° can be judged only from the course of the first tenth, and it is evident that beginning with 1,000°, it may take courses whose ordinates for higher temperatures vary enormously. Such an uncertainty it was which affected SECCHI's determination; and

most significant is the result when SECCHI'S observations are reduced by the same law as used by POUILLET. A temperature of 1,400° is thus obtained from the same numbers, which with the application of another law by SECCHI gave 10,000,000°.

The famous NEWTON was the first to investigate the relation between radiation and the temperature of the radiating body. He came to the conclusion that the rate of cooling of a radiating body is directly proportional to the difference in temperature between the radiating body and the bodies surrounding it. It is assumed here that the radiating body is of a uniform temperature throughout, and that its power of emitting heat is infinitely great. These ideal conditions are the more nearly satisfied the slower is the cooling of the surface, *i. e.* the smaller is the temperature difference. They are not satisfied in the case of the Sun, although it cannot be denied that with a body gaseous at the surface, like the Sun, the convection currents of the gas may afford a certain approximation to the ideal conditions.

It has been shown that NEWTON'S law of cooling can be considered only as a rough approximation, applicable for small temperature differences, but quite misleading when these differences are large. In recent times the most various attempts have been made to determine a law which should be valid for the highest temperatures. The most important of these will now be noticed.

First are the French physicists DULONG and PETIT, who continued NEWTON'S investigations. They found as a satisfactory law for the temperature interval of 280° used by them, that the amount of heat radiated by a body diminished according to a geometrical progression with a uniform diminution of temperature. No theoretical considerations can be advanced in favor of the applicability of this purely empirical law to higher temperatures; and to-day there is no doubt that values of the solar temperature extrapolated by means of this law are too small, but not in the degree in which values obtained by NEWTON'S law are too large. It may be remarked that POUILLET computed according to the law of DULONG and PETIT, while SECCHI used NEWTON'S law.

A second law applicable to temperatures between 0° and 300° was deduced by ROSETTI; its form involves a mathematical expression not easily expressed in words.

Only during the last decades have considerable advances been

made in the determination of the form of this law. First among them is the somewhat complicated mathematical form found by WEBER, a Swiss, which represents satisfactorily all the experimentally deduced relations up to 1,000°, but which is not susceptible of a theoretical interpretation. The Austrian physicist STEFAN has determined an extremely simple law, which, with a slight modification, retains its validity to 1,300°, as shown by recent tests by the Berlin physicists LUMMER and PRINGSHEIM. STEFAN'S law states simply: The amount of heat radiated by a body is proportional to the fourth power of its absolute temperature—to the 3.96 power according to LUMMER and PRINGSHEIM. Besides the extreme simplicity of this law, there is the circumstance that BOLTZMANN has been able to establish it theoretically, from the electro-magnetic theory of light and the mechanical theory of heat.

It is of especial importance to note that the two last-named laws of WEBER and STEFAN differ so slightly for the highest temperatures yet investigated, that it is extremely probable the values obtained by extrapolation in their application to the Sun will be near the true values.

It is possible to conclude from the agreement of the laboratory experiments that the resulting solar temperatures will not vary by more than half the true value, which, in view of the difficulties of the problem, is really a satisfactory solution. With the application of one of these laws, it is therefore possible to bring order into the chaos of solar temperatures, as is shown by the following list, computed according to STEFAN'S law:—

OBSERVER.	SOLAR TEMPERATURE.
POUILLET	5,600°
SECCHI	5,400
VIOLLE	6,200
SORET	5,500
LANGLEY	6,000
WILSON and GRAY	6,200
PASCHEN	5,000
ROSETTI	10,000 { according to his own law.

There is here doubtless justification for the assumption that the solar temperature is greater than 5,000° and less than 10,000°; the value T = 6,250° corresponds to the mean of the above determinations.

The reader will perhaps breathe again in the hope that he is now to be released from the difficulties of the discussion of the solar temperature; but this hope is unfortunately not to be satisfied, for the value T thus obtained represents in no way the temperature of the photosphere as it was in the beginning defined, but only that temperature which the photosphere would have on the assumption that the radiation has come unimpeded to the Earth. But the Sun possesses an atmosphere which, similarly to that of the Earth, absorbs a portion of the radiation; the actual temperature is therefore higher than the value we have obtained. That such an atmosphere exists is shown by the direct view of the Sun through a telescope. Thus seen, the disc is not uniformly bright, as it must be in the case of a simple glowing sphere, but at the edges is much darker, owing to the longer path through the Sun's atmosphere which must be traversed by the rays here than at the center. It is possible to compute the relative lengths of the latter through the atmosphere for different points of the disc, which, combined with the directly observed increase in absorption toward the limb, leads to the law of absorption, and thus it is possible to compute the total absorption of heat rays due to the Sun's atmosphere. Observations have shown that, as in the case of the Earth's atmosphere, different kinds of rays are very differently absorbed — the nearer they lie to the violet end of the spectrum, the greater is the absorption. The rays lying at the other end of the spectrum are least absorbed, though even here very considerably, since the most careful observations by H. C. VOGEL, and the recent determination of FROST show that the transmission coefficient lies between 0.72 and 0.79. It is therefore necessary to multiply the determined radiation by 1.5 in order to get the true value, which increases the solar constant to 5.6 calories. How the solar temperature is now to be computed is as yet undetermined, for STEFAN'S law is no longer applicable; we may *assume* that T lies between 7,000° and 10,000°.

For a comparison with terrestrial temperatures, it may be remarked that the temperature of the electric arc varies from 3,000° to 3,500°; the temperature of a very long electric spark is much higher, running up to 20,000°, and even higher.

(To be concluded in No. 65.)

NEW OBSERVATIONS OF THE OTTO STRUVE DOUBLE STARS.

By W. J. Hussey.

Early in the history of the Pulkowa Observatory a plan of work for the meridian-circle, afterwards materially modified, contemplated the exact determination of the places of all stars of the Northern Hemisphere to the seventh magnitude, inclusive. At that time there was no complete list of such stars, and to form one, giving their approximate places, was the first step in this piece of work. The formation of this preliminary catalogue was undertaken by Otto Struve. With the help of two assistants, he made the necessary observations, with the 15-inch refractor, between August 26, 1841, and December 7, 1842. In this short interval he examined with the finder of the large telescope every portion of the sky north of the celestial equator, and selected the stars (about 17,000 in number) to be included in the catalogue. Each one selected was brought to the center of the field of view of the large telescope, and its approximate position was obtained by noting the time and the readings of the hour and declination circles; at the same time it was carefully examined, to see whether it was double. This examination resulted in a list of 514 objects known, or thought to be, double or multiple, and new to science. In this list, the distances between the components were all to be less than 32″, and the magnitude of the principal star, or, in the case of close doubles, the combined magnitudes of the two, did not descend below 7.8. As companions, all objects at distances less than 16″, and bright enough to be readily measurable with the 15-inch telescope, were admitted; while for distances between 16″ and 32″ the limiting inferior magnitude of the companion adopted was 8.9.

This list of double stars, discovered at Pulkowa, was first published in 1843. Between this time and 1850, sixteen additional pairs were discovered, and were included in the second edition, published in 1850, under the title "Catalogue revu et corrigé des étoiles doubles, decouvertes à Poulkowa." Subsequently other discoveries were made, increasing the list to a total of 547 objects, which are now known as the Otto Struve double stars, or as the double stars of the Pulkowa catalogue. They are denoted by the symbol OΣ.

Many of the 17,000 stars of the preliminary catalogue were examined under poor atmospheric conditions. On this account a large number of important pairs were overlooked, and on the other hand a considerable number of stars were admitted to the list of 514 which were of a very doubtful character. A careful examination of these under better atmospheric conditions led to the rejection of 106 of them, either on account of their being single or having distances surpassing the limits adopted, or having companions too faint for exact micrometric measurement with the 15-inch telescope, or because of clerical errors in the readings or records, due in part, perhaps, to the notation employed in the formation of the catalogue. These 106 stars were omitted in the second (1850) edition of the Pulkowa catalogue, and are known as the Otto Struve rejected stars.

Volume IX of the Pulkowa Publications contains the double-star observations made by OTTO STRUVE during a period of thirty-seven years, from the establishment of the Pulkowa Observatory, in 1839, to 1875. A section of this work is devoted to the 441 Otto Struve stars not rejected, and contains about 2,080 observations of them. Nearly all these stars were first observed in the three or four years immediately following 1843. After the beginning of 1852 only about half of the stars were observed, after 1860 less than a third, and after 1870 less than one-fifth.

A second series of measures of equal importance was made by Baron DEMBOWSKI between 1865 and 1878. In spite of the small size of his instrument (7½ inches aperture) he succeeded in obtaining excellent measures of all but the most difficult of these stars. Out of the 547 objects enumerated in the Pulkowa catalogue, he measured 432, making altogether 2,155 observations of them.

These are the only large, and in a measure complete, series of observations of these stars that have been published. Certain of them have been observed many times by different observers. These are, in general, those which have proved to be binaries, and those which have shown sufficient motion to make it desirable to have a fairly continuous series of measures of them.

Early in the present year, I began to measure the Otto Struve stars for the purpose of obtaining for this epoch determinations of the relative positions of all of them that are given in Vol. IX of the Pulkowa Publications. I subsequently added to

this list such of the rejected stars as were measured by DEMBOWSKI, and some others which OTTO STRUVE rejected as single, but which other observers have since found to be double. The observing list, as thus made up, contains nearly five hundred stars, and it will require some 1,700 or 1,800 observations to obtain complete sets of measures of all of them.

The conditions have been favorable for the prosecution of this piece of work. During the past eight months I have made about 1,350 observations of 414 different stars. Three hundred and forty-one stars have been observed on three or four nights each, and are regarded as finished. It is the plan to continue the work until, in general, each star has been measured on at least three different nights.

Most of the observations are being made with the 12-inch telescope. All difficult pairs are, however, measured with the 36-inch refractor. Measurements are made only on nights when the conditions are favorable for securing good results.

The following notes relate to some of the stars that I have found of interest:

The observations of OΣ 283, by OTTO STRUVE and DEMBOWSKI, give rather discordant distances. I attempted to measure it with the 12-inch telescope, but found it difficult to obtain satisfactory measures of distance with that instrument. On examining it with the 36-inch refractor, I found the faint star a close double; distance, 1″.27; magnitudes, 11½ and 12; and the line joining them making an angle of about 10° with that which connects the principal star with the brighter of the faint components. With this configuration, it is probable that the presence of the fainter companion, by reason of its not being clearly seen, has an influence on the distance measures made with small telescopes.

Some months ago, I found OΣ 341 single (see these *Publications*, Vol. X, p. 121,) whereas the observations from 1845 to 1886 had seemed to indicate that the two components were relatively fixed at a distance of about 0″.4 or 0″.5. A recent observation, 1898, 707, shows an elongation 0″.09, and a change of quadrant, 254°.3. The smaller star has already passed periastron, and an increase of distance may now be expected.

While observing OΣ 351, I discovered the south component to be a close double, of which I have made the following measures:—

1898.572	309°.9	0″.33
592	307 .6	0 .36
595	312 .9	0 .32
707	309 .6	0 .36
1898.62	310°.0	0″.34

The north star A is decidedly brighter than B, though less bright than B and C combined. These considerations reverse the quadrant of the OΣ pair as given by previous measures. The Otto Struve pair has a distance of about 0″.6, and its components have shown no certain motion. In a private letter, Professor BURNHAM states that he can recall no other instance of three stars so close together. I have, however, more recently found another case. It is that of OΣ 476.

The north component of OΣ 476 is a very close double. My measures are as follows:—

1898.630	227°.7	0″.15
690	229 .5	0 .17
707	224 .4	0 .13
1898.68	227°.2	0″.15

In this case the Otto Struve pair has a distance of 0″.54, and has shown no motion.

I have looked very carefully for OΣ 546 on several occasions with both the 12- and 36-inch telescopes without finding it. DEMBOWSKI had a similar experience. In the Pulkowa catalogue of 5,634 stars, ROMBERG gives number 4093 as OΣ 546. I have examined this star, and do not find it double. OTTO STRUVE measured OΣ 546 but once, and speaks of its being near Σ 2396. The measure he gives, including position angle, distance, magnitudes of components, and position in the sky, all agree so closely with those of OΣ 362 as to make it highly probable that it is identical with the latter.

LICK OBSERVATORY, September 18, 1898.

THE MOTION OF η *CEPHEI* IN THE LINE OF SIGHT.

BY W. W. CAMPBELL.

In the course of our determinations of stellar velocities in the line of sight, I have found that the star η *Cephei* has a very great velocity toward the solar system. Four spectrum plates of this star have been secured and measured by Mr. WRIGHT and myself. They yield the following velocities in kilometers per second:—

	— 87.6
	— 87.2*
	— 86.2
	— 86.9
	— 86.2
Mean	— 86.8

The equivalent in English miles is — 53.9.

The motion of η *Cephei* at right angles to the line of sight is about 0.8 second of arc annually.

We have confirmed the results† obtained by Dr. BELOPOLSKY, at Pulkowa, for the star ζ *Herculis*. Our results from four plates, together with those previously obtained by Dr. BELOPOLSKY from seven plates, are as follows:—

	BELOPOLSKY.	CAMPBELL.
	— 68 km.	— 69.1 km.
	— 84	— 70.4
	— 75	— 70.0
	— 67	— 71.1‡
	— 66	— 70.9
	— 64	
	— 69	
Means	— 70 km.	— 70.3 km.

The equivalent result in English miles is — 43.7.

It should be noticed that these stars are situated in the part of the sky toward which the solar system is moving, and the above results are the sums of the stars' motion toward our system, and of our system toward them. If we assume that the solar system is

* Measure of the same plate by Mr. WRIGHT.

† Published in *Astronomische Nachrichten*, No. 3184.

‡ Measure of the same plate by Mr. WRIGHT.

moving toward the point in the sky whose Right Ascension is 267° and whose Declination is + 31°, with a velocity of 17 kilometers per second, then the solar components toward η *Cephei* and ζ *Herculis* are respectively 12.7 and 16.4 kilometers per second. Applying these corrections, the velocities of these stars with reference to the sidereal system become—

for η *Cephei*, — 74.1 km. per second.
for ζ *Herculis*, — 53.9 km. per second.

Their equivalents in English miles are —46.0 and — 33.5.

(THIRTIETH) AWARD OF THE DONOHOE COMET-MEDAL.

The Comet-Medal of the Astronomical Society of the Pacific has been awarded to E. F. CODDINGTON, Fellow in Astronomy at the Lick Observatory, for his discovery of an unexpected comet on June 11, 1898.

The Committee on the Comet-Medal,
JAMES E. KEELER,
WM. M. PIERSON,
CHAS. BURCKHALTER.

August 11, 1898.

(THIRTY-FIRST) AWARD OF THE DONOHOE COMET-MEDAL.

The Comet-Medal of the Astronomical Society of the Pacific has been awarded to C. D. PERRINE, Assistant Astronomer in the Lick Observatory, for his discovery of an unexpected comet on June 14, 1898.

The Committee on the Comet-Medal,
JAMES E. KEELER,
WM. M. PIERSON,
CHAS. BURCKHALTER.

August 14, 1898.

(THIRTY-SECOND) AWARD OF THE DONOHOE COMET-MEDAL.

The Comet-Medal of the Astronomical Society of the Pacific has been awarded to E. GIACOBINI, of the Observatory, Nice, France, for his discovery of an unexpected comet on June 18, 1898.

The Committee on the Comet-Medal,
JAMES E. KEELER,
WM. M. PIERSON,
CHAS. BURCKHALTER.

August 18, 1898.

PLANETARY PHENOMENA FOR NOVEMBER AND DECEMBER, 1898.

By Professor Malcolm McNeill.

Mercury is an evening star, and toward the end of the month it remains above the horizon an hour or more after sunset, and may be seen under favorable weather conditions. On November 19th it is in conjunction with *Venus*, passing 1° 18′ north of the latter. As the planets then set less than an hour after the Sun, it will be difficult to see them, unless the horizon is very free from cloud and haze.

Venus is still an evening star, but is rapidly approaching inferior conjunction with the Sun, and after the middle of the month it will not be easy to see it. At the beginning of the month it has just passed its period of greatest brilliancy.

Mars rises earlier, before 9 o'clock, at the end of the month. It moves about 8° eastward during the month through the constellation *Cancer*. On November 11th it passes less than half of the Moon's diameter south of the fifth-magnitude star *η Cancri*. Its distance from the Earth decreases more than 20,000,000 miles during the month, and at the close is about 77,000,000. Its brightness increases about sixty per cent.

Jupiter is a morning star, and rises from one to three hours before sunrise according to the time of the month. It is in the eastern part of the constellation *Virgo*, and moves about 6° eastward and 2° southward during the month.

Saturn is still an evening star, and is not far enough away from the Sun toward the end of the month to be seen. It is in conjunction with *Venus* on November 23d, passing 4° to the north of the latter; but both planets are too near the Sun to be easily seen.

Uranus is in conjunction with the Sun and changes from an evening to a morning star on November 25th, but remains too near the Sun to be seen.

Neptune is above the horizon nearly the entire night, and is on the border line between *Taurus* and *Gemini*.

December.

The winter solstice comes and winter begins December 21st, 11 A.M. P. S. T.

Eclipses. There will be two eclipses during the month. The first is a partial eclipse of the Sun on December 13th. It is visible only in the South Pacific Ocean, and its greatest magnitude is only a little more than one-fortieth of the Sun's diameter.

The second is a total eclipse of the Moon on December 27th, and will, in part at least, be visible throughout the entire country. Total eclipse will end at $4^h\ 27^m$ P.M. Pacific time, just about the time the Moon rises in the extreme western part of the United States.

Mercury is an evening star at the beginning of the month, and comes to greatest eastern elongation on December 3d. For the first ten days of the month it sets an hour or more later than the Sun, and may be seen in the evening twilight on a clear evening. After that, it rapidly approaches the Sun, and passes inferior conjunction on December 21st, becoming a morning star. At the end of the month it rises an hour and a half before sunrise.

Venus passes inferior conjunction with the Sun on December 1st, and becomes a morning star. By December 10th it rises more than hour before sunrise, and after that it may be seen in the morning twilight.

Mars is getting into better position for evening observation, rising before 9 o'clock on December 1st, and more than two hours earlier on December 31st. It moves eastward about 1° until December 10th, and then moves westward 3° and northward 2° before December 31st. Its line of backward motion is about 2° north of the line it traced moving eastward in November. On December 29th, it passes about the Moon's diameter north of the fifth magnitude star γ *Cancri.* During the month its distance from the Earth diminishes about 14,000,000 miles, and is about 63,000,000 at the close. Its brightness increases about fifty per cent. during the month.

Jupiter rises about two hours earlier than during the corresponding period of November, at 2:20 A.M. on December 31st. It moves about 3° east and south in the constellation *Virgo.*

Saturn is in conjunction with the Sun on December 6th, and becomes a morning star. It remains near the Sun, but may possibly be seen toward the close of the month in the morning twilight.

Uranus is a morning star also, but its faintness precludes its being seen until its distance from the Sun is greater.

Neptune comes to opposition with the Sun on the evening of December 14th.

Phases of the Moon, P. S. T.

		H. M.		H. M.
Last Quarter,	Nov. 6,	6 28 A. M.	Dec. 6,	2 6 A. M.
New Moon,	Nov. 13,	4 20 P. M.	Dec. 13,	3 43 A. M.
First Quarter,	Nov. 20,	9 5 A. M.	Dec. 19,	7 22 P. M.
Full Moon,	Nov. 27,	8 39 P. M.	Dec. 27,	3 39 P. M.

The Sun.

1898.	R. A. H. M.	Declination. ° ′	Rises. H. M.	Transits. H. M.	Sets. H. M.
Nov. 1.	14 27	− 14 32	6 34 A.M.	11 44 A.M.	4 54 P.M.
11.	15 7	− 17 31	6 45	11 44	4 43
21.	15 48	− 20 0	6 57	11 46	4 35
Dec. 1.	16 31	− 21 52	7 8	11 49	4 30
11.	17 14	− 23 2	7 17	11 54	4 31
21.	17 59	− 23 27	7 23	11 58	4 33
31.	18 43	− 23 5	7 26	12 3 P.M.	4 40

Mercury.

Nov. 1.	14 58	− 17 35	7 15 A.M.	12 14 P.M.	5 13 P.M.
11.	16 0	− 22 17	7 57	12 37	5 17
21.	17 3	− 25 9	8 34	1 1	5 28
Dec. 1.	18 1	− 25 48	8 56	1 20	5 44
11.	18 34	− 24 12	8 42	1 13	5 44
21.	18 3	− 21 23	7 20	12 3	4 46
31.	17 25	− 20 8	5 56	10 45 A.M.	3 34

Venus.

Nov. 1.	16 54	− 27 57	9 57 A.M.	2 11 P.M.	6 25 P.M.
11.	17 2	− 27 36	9 24	1 40	5 56
21.	16 54	− 25 58	8 28	12 51	5 14
Dec. 1.	16 32	− 22 58	7 13	11 50 A.M.	4 27
11.	16 10	− 19 34	5 59	10 50	3 41
21.	16 2	− 17 17	5 2	10 2	3 2
31.	16 10	− 16 35	4 28	9 30	2 32

Mars.

Nov. 1.	8 13	+ 21 28	10 13 P.M.	5 30 A.M.	12 47 P.M.
11.	8 27	+ 21 1	9 50	5 5	12 20
21.	8 38	+ 20 44	9 23	4 37	11 51 A.M.
Dec. 1.	8 45	+ 20 43	8 51	4 5	11 19
11.	8 48	+ 21 2	8 13	3 28	10 43
21.	8 44	+ 21 42	7 29	2 46	10 3
31.	8 35	+ 22 41	6 36	1 58	9 20

Jupiter.

Nov. 1.	13 33	− 8 32	5 19 A.M.	10 50 A.M.	4 21 P.M.
Dec. 1.	13 56	− 10 42	3 52	9 15	2 38
31.	14 6	− 12 24	2 20	7 37	12 54

Saturn.

Nov. 1.	16 37	− 20 38	9 7 A.M.	1 54 P.M.	6 41 P.M.
Dec. 1.	16 52	− 21 7	7 25	12 10	4 55
31.	17 7	− 21 30	5 44	10 27 A.M.	3 10

Uranus.

Nov. 1.	16 1	− 20 31	8 30 A.M.	1 17 P.M.	6 4 P.M.
Dec. 1.	16 9	− 20 52	6 42	11 27 A.M.	4 12
31.	16 16	− 21 11	4 53	9 37	2 21

Neptune

Nov. 1.	5 36	+ 22 0	7 35 P.M.	2 54 A.M.	10 13 A.M.
Dec. 1.	5 33	+ 21 57	5 34	12 53	8 12
31.	5 30	+ 21 55	3 29	10 48 P.M.	6 7

Eclipses of *Jupiter's* Satellites, P. S. T.

(Off left-hand limb as seen in an inverting telcscope.)

		H. M.			H. M.
I, D,	Nov. 14.	5 55 A.M.	I, D,	Dec. 7.	6 5 A.M.
II, D,	15.	5 40 A.M.	II, D,	10.	2 36 A.M.
III, R,	19.	3 21 A.M.	I, D,	15.	2 27 A.M.
I, D,	23.	2 17 A.M.	II, D,	17.	5 9 A.M.
III, D,	26.	5 23 A.M.	I, D,	23.	4 21 A.M.
III, R,	26.	7 18 A.M.	I, D,	30.	6 14 A.M.
I, D,	29.	4 11 A.M.	I, D,	Jan. 1.	12 42 A.M.
			III, D,	1.	1 9 A.M.
			III, R,	1.	3 3 A.M.

NOTICES FROM THE LICK OBSERVATORY.*

PREPARED BY MEMBERS OF THE STAFF.

NEW GASES IN THE EARTH'S ATMOSPHERE.

Our readers will remember notices in Vol. VII (pp. 61 and 38) of these *Publications*, calling attention to the discovery by Lord RAYLEIGH and Professor RAMSAY of a new atmospheric gas called by them ***argon***. These investigators and others have continued their researches along the same lines, being aided by the recent improvements made in the process of liquefying air by means of which extremely low temperatures may be produced. The result is the discovery of at least two new gases in the Earth's atmosphere, and of a third which may prove to be new.

Messrs. RAMSAY and TRAVERS communicated to the Royal Society on June 3d of this year a preliminary note on ***krypton***, the first of these new gases. From $750^{\text{cu cm}}$ of liquid air, they obtained $27^{\text{cu cm}}$ of a gas whose spectrum differs from that of any other known element. Besides many feeble lines, the spectrum exhibits two brilliant lines, one at $\lambda\,5869$ (very near the D_3 line) and the other at $\lambda\,5570$.

The properties of the new gas are not yet fully determined, but the discoverers venture the conjecture that its density will turn out to be 40, with an atomic weight of 80. By comparison of the length of a sound-wave in it and in air, krypton is shown to be monatomic and an element.

The coincidence of the line $\lambda\,5570$ with the principal line of the Aurora has been noted by several observers, and it is suggested that we have "at last the true origin of that hitherto perplexing line." In this connection, it is of interest to recall the experiments by LIVEING and DEWAR in passing sparks

* Lick Astronomical Department of the University of California.

through small layers of liquefied oxygen, air, and nitrogen. (See brief review in *Astrophysical Journal*, Vol. I, p. 88.) Under certain conditions of temperature, pressure, etc., the spectrum of liquid oxygen showed a line at λ 5572. "The wave-length of the auroral line is λ 5571.6; and the conditions of temperature and pressure in these experiments must have been somewhat similar to those under which the Aurora appears. This points, of course, to the probability of the auroral line being due to the oxygen of our atmosphere."

Still more recently, Professor RAMSAY and Dr. NORMAN COLLIE succeeded in liquefying a quantity of argon. It formed a colorless fluid, but two other products also resulted. These were a lighter gas which failed to liquefy, and a solid deposit which gathered on the sides of the tube.

The lighter gas was drawn off and its spectrum examined. In Professor RAMSAY'S announcement to the Royal Academy, on June 16th, the spectrum of this gas, called by him *neon*, is described as containing a large number of strong lines in the red, orange, and yellow, and in the deep violet. Experiments to determine its density seemed to indicate that the gas had not been obtained in its pure form.

These two gases are undoubtedly new elements; but the third, obtained from the solid frozen out of the argon, may yet prove to be a new compound of known elements, rather than a new element. This substance, called *metargon* by its discoverers, has a density of 19.87, the density of argon being 19.94. Its spectrum showed many bands whose wave-lengths are closely coincident with those in the band spectrum of carbon and with three cyanogen bands, as was pointed out by Professor SCHUSTER (*Nature*, Vol. LVIII, p. 199).

The spectroscopic evidence is therefore strong that it is some carbon compound rather than a new element. Subsequently (*Nature*, Vol. LVIII, p. 245), Messrs. RAMSAY, TRAVERS, and BALY describe precautions taken, and chemical tests applied, to exclude the possibility of any carbon existing in this gas, and ask for a suspension of judgment pending further investigation.

R. G. AITKEN.

THE MINOR PLANET (334) *CHICAGO*.

This small planet was discovered, photographically, by Professor MAX WOLF, at Heidelberg, August 23, 1892. While

attending the astronomical conferences held in connection with the World's Fair, August, 1893, he gave it the name *Chicago*.

The planet *Chicago* is of more interest than many of the asteroids, by reason of the nearness of its orbit to that of *Jupiter*, and of the large perturbations which it experiences when it is in the vicinity of the latter planet. In 1894, the two planets were near together, their distance being only 1.25 astronomical units. At that time *Jupiter's* perturbing force amounted to $\frac{1}{18}$th of the attractive force of the Sun.

The periodic times of the two planets are very nearly in the commensurable ratio of 2 to 3, the mean daily motion of *Jupiter* being 299".12836, and that of *Chicago*, 455".998. While *Jupiter* makes two revolutions about the Sun, *Chicago* makes slightly more than three. As a result, the consecutive returns of the two planets to those points in their orbits where they are nearest together fall at nearly the same places, allowing the perturbations to have an accumulative effect. These points, however, do not exactly coincide, but move slowly around the orbits, completing a revolution only after a long interval of time. This insures the existence of very sensible inequalities of long period and of considerable changes in the values of some of the elements of the orbit of *Chicago*. The perturbing action of *Jupiter* will cause the eccentricity of the orbit of *Chicago* to decrease until it becomes zero (*Astrophysical Journal*, December, 1897); this orbit will then be truly circular, and as the eccentricity passes on to negative values, the longitude of perihelion will change 180°.

These considerations make it desirable to obtain at each opposition a sufficient number of observations of the planet *Chicago* to form a secure normal place, thus affording the data necessary for the basis and control of the theoretical investigations relating to its orbit. With this object in view, I obtained observations of it on six nights in May and June of the present year with the 36-inch refractor, and on five of these nights observations were also made by Mr. CODDINGTON.

This planet is faint (12.1 magnitude), and at the time our observations were made it was passing through a region of the sky where faint stars of about its brightness are especially numerous. On this account, it would have been a matter of considerable difficulty to find the planet by examining the stars visually for motion, and the more so since it was nearly three-

quarters of a degree from its predicted place. This difficulty was removed by Mr. CODDINGTON, who first photographed the region with the Crocker telescope, giving an exposure of three hours. He identified the planet by means of its trail, and derived an approximate correction to the ephemeris. He next prepared charts of the faint stars shown on his photographic plates, and inserted on them the predicted places of the asteroid for the times at which we intended to observe it. This proved very successful. At the time of the first observation, I selected the planet at the first trial, and within five minutes from the time when the telescope was pointed to the proper field had it identified, by means of its motion. At the times of the other observations we found it with almost equal ease. W. J. HUSSEY.

LICK OBSERVATORY, September 13, 1898.

THE NEW MINOR PLANET, 1898 *DQ*.

The minor planet, 1898 *DQ*, discovered photographically by WITT at the Urania Observatory, Berlin, August 13th, promises to be of unusual interest. According to the preliminary elements of its orbit, computed by BERBERICH, its perihelion lies far within the orbit of *Mars;* and indeed so close does its path come to that of the Earth, that at the place of nearest approach they are separated by less than 15,000,000 miles. When nearest the Earth, the planet's equatorial horizontal parallax is about a minute of arc, exceeding that of any other known body whose position can be measured with the same degree of accuracy. On this account, it will be an excellent object by means of which to determine the solar parallax, and thence the mean distance of the Earth from the Sun. W. J. HUSSEY.

LICK OBSERVATORY, September 27, 1898.

DISCOVERY AND ORBIT OF COMET *h* 1898 (PERRINE).

This comet was discovered in the morning of September 13th. This is the eighth comet to be discovered this year, five being unexpected. The comet's position on the morning of discovery at 0^h 58^m 8^s G. M. T. of Sept. 13th, was α 9^h 35^m $49^s.27$, $\delta + 31^\circ 4' 31''.0$. The comet was then between the two constellations *Leo*, *Major* and *Minor*, and was moving east 6^m per day and south $30'$. Its daily motion is rapidly increasing in both co-ordinates, and thus gaining on the Sun at such a rate that it will probably be lost in the dawn early in October. At the time of discovery, it had a

round head 4′ or 5′ in diameter with a well-marked central condensation, the entire head being about as bright as an eighth-magnitude star. As it is approaching both the Sun and Earth, it is becoming brighter. It has had a narrow tail about ¼° long, pointing away from the Sun. This tail has never been conspicuous, even with the 12-inch refractor. Within the last few days a sharp nucleus has developed. This nucleus was noted as stellar on September 20th, when the seeing was best, and of about the tenth magnitude. From observations secured here on September 12th, 13th, and 14th, the following preliminary orbit was computed by R. G. AITKEN and the writer:—

$$\begin{aligned} T &= 1898,\ \text{October } 20.0168 \text{ G. M. T.} \\ \omega &= 165^\circ\ 16'\ 48'' \\ \Omega &= \ \ 36\ \ \ \ 5\ \ \ 29 \\ i &= \ \ 29\ \ \ 12\ \ \ 14 \\ \log q &= 9.58456 \end{aligned} \left.\vphantom{\begin{aligned}\omega\\ \Omega\\ i\end{aligned}}\right\} \text{Ecliptic and Mean Equinox of 1898.0}$$

Residuals for the middle place were:

$$(O-C):\quad \Delta\lambda' \cos\beta' \quad +3''$$
$$\Delta\beta' \quad -1$$

From these elements it will be seen that the comet makes its nearest approach to the Sun on October 20th, at a distance of 36,000,000 miles. An ephemeris from these elements shows that the comet is becoming rapidly brighter, being three times as bright as at discovery, on September 30th, the last date of the ephemeris.

These elements bear no special resemblance to any known comet. C. D. PERRINE.

September 22, 1898.

NEW ELEMENTS OF COMET *h* 1898.

From the Mount Hamilton observations of this comet at discovery, September 12th, and on September 17th and 22d, I have derived the following parabolic elements:—

$$\begin{aligned} T &= 1898,\ \text{October } 20.53478 \text{ G. M. T.} \\ \omega &= 162^\circ\ 26'\ 8''.3 \\ \Omega &= \ \ 34\ \ \ 55\ \ \ 37\ .5 \\ i &= \ \ 28\ \ \ 51\ \ \ 27\ .2 \\ \log q &= 9.622688 \end{aligned} \left.\vphantom{\begin{aligned}\omega\\ \Omega\\ i\end{aligned}}\right\} \text{Ecliptic and Mean Equinox of 1898.0}$$

Residuals for the middle observation:

$$(O-C):\quad \Delta\lambda' \cos\beta' \quad +0''.4$$
$$\Delta\beta'' \quad -1\ .0$$

On October 22d, the comet is in conjunction with the Sun in R. A. and becomes an evening object. It should be again visible from southern stations (only) about November 1st and for a month after. Its greatest theoretical brightness will be on October 20th, at the time of its passing perihelion, when it will be seven times as bright as at discovery. On September 23d, it was just visible to the naked eye against a dark sky. Some of the absolute dimensions may be of interest. The head is 4′ in diameter, as seen with the 12-inch telescope, which corresponds to an actual diameter of 150,000 miles. With the same telescope, the tail can be traced for ¼° (the tail is in all probability several times this length), or a length of about 600,000 miles. After passing perihelion, the comet will be close to the planet *Mercury* for a week or more, the distance ranging from 6,000,000 to 8,000,000 miles. The longitudes and distances from the Sun of both *Mercury* and the comet are very nearly the same, but owing to their different nodes, inclinations, and motions in their orbits, they do not make as close an approach as otherwise they would. At this distance of 6,000,000 miles, the comet would be a striking object as seen from *Mercury*, the head 1½° in diameter, the tail 5° or 6° in length. The brightness would be over 150 times that on September 27th as seen from the Earth, when it was visible to the unaided eye. This would make it more conspicuous than a first-magnitude star. C. D. PERRINE.

September 28, 1898.

ELEMENTS OF THE MINOR PLANET, 1898 *DQ*.

From the mean of the two Kiel observations of August 15th by Dr. RISTENPART, and my own observations of September 6th and 27th, I have computed the following elements of this interesting planet:—

Epoch 1898, August 31.5 G. M. T.

$$M = 222^\circ\ 51'\ 53''.3$$

$$\left.\begin{aligned} \omega &= 176\ \ 52\ \ 17\ .6 \\ \Omega &= 303\ \ 23\ \ 45\ .2 \\ i &= \ \ 10\ \ 44\ \ 43\ .3 \end{aligned}\right\} \text{Ecliptic and Mean Equinox of 1898.0}$$

$$\phi = 12\ \ 49\ \ 40\ .7$$

$$\log a = 0.164038$$

$$\mu = 2013''.491$$

$$\text{Period} = 643.66 \text{ days} = 1.76 \text{ years.}$$

In obtaining these elements, the observations were fully corrected for parallax and aberration. The interval embraced by the observations is 43 days; during this time the planet described a heliocentric arc of about 17°.

According to these elements, the perihelion distance of this planet is only 105,440,000 miles, or nearly 23,000,000 miles less than that of *Mars*, and only 11,000,000 greater than the aphelion distance of the Earth. Its periodic time is nearly a year less than that of any other asteroid. W. J. HUSSEY.

ASTRONOMICAL TELEGRAMS.

(Translations.)

BOSTON, Mass., September 5, 1898.

To Lick Observatory: (Received 9:50 P. M.)

KREUTZ announces planet *DQ* remarkable orbit. Perihelion within *Mars'* orbit. Element μ [= daily motion] 2,000″.

(Signed) JOHN RITCHIE, Jr.

[A further note on this asteroid will be found on another page of this number. The telegram included an ephemeris, which is here omitted.]

Lick Observatory, September 13, 1898.

To Harvard College Observatory:
To Students' Observatory, Berkeley: } (Sent 10 A. M.)

A bright comet was discovered by C. D. PERRINE, September 13.040 G. M. T., in R. A. $9^h\ 33^m\ 53^s$; Decl. $+31°\ 4'$. The daily motion in R. A. is $+6^m$; in Decl. $-30'$.

Lick Observatory, September 14, 1898.

To Harvard College Observatory:
To Students' Observatory, Berkeley: } (Sent 2:51 P. M.)

Comet PERRINE was observed by C. D. PERRINE on September 13.0404 G. M. T.; in R. A. $9^h\ 35^m\ 49^s.3$; Decl. $+31°\ 4'\ 31''$; and on September 14.0145 G. M. T.; in R. A. $9^h\ 41^m\ 43^s.8$; Decl. $+30°\ 35'\ 19''$.

BOSTON, Mass., September 14, 1898.

To Lick Observatory: (Received 2:10 P.M.)

A faint comet was discovered by PECHÜLE, at Copenhagen, on September 13.6230 G. M. T.; in R. A. $6^h\ 38^m\ 3^s.5$; Decl. $+8°\ 55'\ 40''$. Its daily motion in R. A. is $+30'$; in Decl. $-20'$. It is probably Comet TEMPEL, 1866 I.

(Signed) JOHN RITCHIE, Jr.

BOSTON, Mass., September 14, 1898.

To Lick Observatory: (Received 9:22 P. M.)

Comet PECHÜLE is WOLF'S comet, not TEMPEL'S.

(Signed) J. RITCHIE, Jr.

BOSTON, Mass., September 15, 1898.

To Lick Observatory: (Received 10 A. M.)

There is some uncertainty in your telegram. First position does not check. Repeat it. Is comet new?

(Signed) JOHN RITCHIE, Jr.

[In answer to this telegram, part of the telegram of September 14, 2:51 P. M., given above, was repeated with the addition of the word "new" before comet. The telegram on file in the W. U. office in San Jose was read by the operator and found to be correct.]

Lick Observatory, Sept. 15, 1898.

To Harvard College Observatory:
To Students' Observatory, Berkeley: (Sent 10 A. M.)

Comet PERRINE was observed by C. D. PERRINE on September 14.9768 G. M. T., in R. A. $9^h\ 47^m\ 36^s.8$; Decl. $30^\circ\ 4'\ 57''$.

Lick Observatory, September 15, 1898.

To Harvard College Observatory: (Sent 1:10 P. M.)

Elements and ephemeris of Comet PERRINE were computed by C. D. PERRINE and R. G. AITKEN as follows:—

$$T = 1898,\ \text{October } 20.02\ \text{G. M. T.}$$

$$\left.\begin{aligned} \omega &= 165^\circ\ 17' \\ \Omega &= \ \ 36\ \ \ \ 5 \\ i &= \ \ 29\ \ \ 12 \end{aligned}\right\} \begin{array}{c}\text{Ecliptic and} \\ \text{Mean Equinox of 1898.0}\end{array}$$

$$\text{natural } q = 0.3842$$

[The ephemeris is here omitted.]

THE PERSEID SHOWER OF 1898.

Meteors from this radiant became noticeable on the night of August 8th. The night of August 9th was partly cloudy, but a number of meteors were seen in the early part of the evening. Thin clouds still interfered on the night of the 10th, but a larger number of meteors than usual from this radiant was observed. After the Moon rose it became clear overhead, and from $14^h\ 25^m$

to $14^h\ 55^m$ fifty-one meteors were counted, of which all but four were *Perseids*. This frequency was estimated to be about an average for the latter portion of the night. C. D. PERRINE.

LICK OBSERVATORY,
UNIVERSITY OF CALIFORNIA, August 16, 1898.

ELEMENTS OF COMET *e* 1898 (PERRINE).

The following system of parabolic elements of this comet has been derived from normal places for the dates June 16.0, July 12.0, and August 7.0. The observations used in forming the normal places were: Mount Hamilton, June 14, 15, 16, 17; Paris, June 16; Strassburg, June 17; Mount Hamilton, July 9, 11, 12, 13, 14; Mount Hamilton, August 2, 4, 5, 6, 7, 8.

ELEMENTS.

$$
\begin{aligned}
T &= 1898,\ \text{August } 16.19978 \text{ G. M. T.} \\
\Omega &= 259^\circ\ \ 6'\ \ 12''.2 \\
\omega &= 205\ \ 36\ \ 24\ .0 \\
i &= 70\ \ \ 1\ \ 36\ .7
\end{aligned}
\left.\vphantom{\begin{aligned}\Omega\\\omega\\i\end{aligned}}\right\}
\begin{array}{l}\text{Ecliptic and} \\ \text{Mean Equinox 1898.0}\end{array}
$$

$$\log q = 9.796950$$

The residuals for the middle place are:—

Observed — Computed,

$$
\begin{array}{ll}
\Delta\lambda' \cos\beta' & +0''.1 \\
\Delta\beta' & -0\ .9
\end{array}
$$

The comet was last observed at Mount Hamilton on the morning of August 11th, when it was well into the dawn. It would not have been visible except for its increased brightness and sharp nucleus. On August 7th, the nucleus of the comet was estimated to be nearly as bright as the 9.1-magnitude comparison star. The light of the entire comet probably equaled a seventh-magnitude star. The comet has now passed out of range of northern observatories, but should be visible in the Southern Hemisphere for two months yet. The orbit of this comet bears a resemblance to that of the PONS-BROOKS comet of 1812–1884. There is also considerable resemblance to the orbit of the comet 1785 I, especially in ω and i. Comet *e* is so plainly parabolic, that the resemblance must be considered as merely placing them in a group, probably with no physical connection. C. D. PERRINE.

LICK OBSERVATORY,
UNIVERSITY OF CALIFORNIA, August 25, 1898.

Obituary Notice.

Dr. Hermann Romberg died in Berlin on July 6, 1898. From Professor Backlund's note in *Astronomische Nachrichten*, 3512, we condense the following brief account of his life and work.

Born in 1835 at Bromberg, he received his university training at Berlin, coming under Encke's guidance in astronomy. After a number of years' experience as assistant in several observatories, particularly at Berlin, where he took part in the observations for the Astronomische Gesellschaft Zone Catalogue, he was called to Pulkowa in 1873. He here found, in the use of the large Repsold meridian-circle, which was intrusted to him, his true field of labor, and for twenty-one years he worked with the utmost assiduity. The amount of work he accomplished—9,000 complete meridian observations a year, in some years—seems marvelous, especially when the climatic disadvantages of Pulkowa are considered, and the further fact that these were not zone observations, but included selected stars ranging in Declination from $-25°$ tó the North Pole.

His zeal and success in the work of reducing his observations were equally great, and the fruits of his labors will be found in three splendid star catalogues. The first of these, based on 32,000 observations made in 1874–1880, is his well-known catalogue of 5,634 stars. Two further volumes will contain the observations made in the years 1881–1894. One of these, including about 20,000 observations, is now in press; the other, containing 15,000 observations, is ready for the press. These volumes will form Romberg's most enduring monument.

The key-note of his personal character was a fearless rectitude that knew no compromise with any form of deception. Convinced of the truth and righteousness of a given course of action, he followed it unswervingly, despite occasional unpleasant consequences to himself. With this he combined great gentleness and friendliness of disposition, and a stanch loyalty to his friends that endeared him to many.

Minutes of the Meeting of the Board of Directors, held at the Lick Observatory, September 3, 1898.

President Aitken presided. A quorum was present. The minutes of the last meeting were approved. The following members were duly elected:—

List of Members Elected September 3, 1898.

Mr. W. A. Dawson	Horatio, Arkansas.
Prof. L. A. Jolivet, M. D.	Director Little Seminary, Mt. Loretto, S. I., New York.

Mr. Henry B. Loomis, of Seattle, Washington, was elected to life-membership.

Adjourned.

Minutes of the Meeting of the Astronomical Society of the Pacific, held at the Lick Observatory, September 3, 1898.

President Aitken presided. The minutes of the last meetlng were approved. The Secretary read the names of the new members elected at the Directors' meeting.

The following papers were presented:—

1. Planetary Phenomena for November and December, 1898, by Prof. Malcolm McNeill.
2. A Star with a very Large Velocity in the Line of Sight, by Prof. W. W. Campbell.

Adjourned.

NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only. Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book-keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the *Publications* for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of two dollars per volume to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to the Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the card.

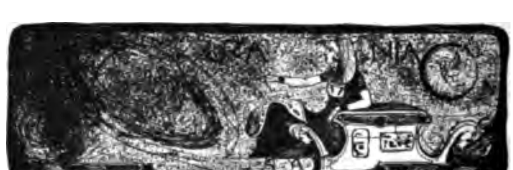
The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States. The responsibility for the views expressed in the papers printed rests with the writers, and is not assumed by the Society itself.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery, stamped with the seal of the Society, at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific" at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.

PUBLICATIONS ISSUED BI-MONTHLY.

(February, April, June, August, October, December.)



THE BRUCE GOLD MEDAL.

PUBLICATIONS

OF THE

Astronomical Society of the Pacific.

VOL. X. SAN FRANCISCO, DECEMBER 1, 1898. NO. 65.

A GENERAL ACCOUNT OF THE CHABOT OBSERVATORY-PIERSON ECLIPSE EXPEDITION TO INDIA.

By CHARLES BURCKHALTER.

It was by the public spirit and generosity of a valued member of this Society, Past-President WM. M. PIERSON, and the kindness and liberality of the Board of Education of the city of Oakland, that it was possible to send an expedition from the Chabot Observatory to India to observe the total eclipse of the Sun, on January 22, 1898.

Mr. PIERSON not only gave me more money than I had estimated as necessary, but had me arrange a telegraphic code, so I could send for more in an emergency, and then, as though this were not enough, he said, "Of course, your family will come to me if they need anything while you are away!"

J. W. MCCLYMONDS, Superintendent of Schools and Director of the Observatory, Mr. YORK, Assistant Superintendent, and W. C. GIBBS, of this city, gave me needed help, and Mr. HENRY KAHN, of San Francisco, loaned me valuable instruments for the expedition.

Knowing by experience on the expedition to the island of Yezzo, in 1896, that steel rails and the most delicate astronomical instruments look alike to the coolies who handle freight in the Far East, I was much concerned lest an accident should happen to the objective of the Pierson photographic telescope, presented to this Observatory by Mr. PIERSON, in 1895, for the expedition to Japan — which would cause the failure of the expedition. I resolved to procure, if possible, a duplicate lens, and appealed in

this emergency to a member of the Society, Dr. GEORGE C. PARDEE, of this city, who readily consented to present the extra objective, and it was ordered at once from BRASHEAR, the maker of the Pierson lens. As in all probability both objectives would reach the station safely, I fitted a tube for the new lens, which, with plate-holders, exposure-shutters, etc., was also provided by Dr. PARDEE, and mounted it upon the Pierson tube, thereby having two important instruments, the new lens to be used to obtain a duplicate set of negatives, the exposures in both telescopes, being electrically controlled, being identical. The plates in the Pierson telescope having the exposures controlled by a diaphragm, and the Pardee plates being exposed in the ordinary way, would thus give strictly comparable negatives. All the work of preparation, including a new and novel equatorial mounting, was done with my own hands, during leisure time, my regular work being carried on until two weeks before sailing.

After an amount of preparation, detail, and anxiety, only to be appreciated by those who have undertaken similar expeditions, I sailed, all alone, for "a point or points in India," as the insurance policy on the instruments declared, with nearly two tons' measurement of apparatus to look after and be responsible for getting to the proper place and adjustment, and successfully managing the thousand details that go to make up an expedition. I sailed from San Francisco on October 30th, in the fine steamer *Belgic*, and had the exclusive use of a good stateroom, Mr. PIERSON himself coming down to the ship to see that I lacked for nothing.

The ship called and stopped from one to three days at Honolulu, Yokohama, Kobe, Nagasaki, and Shanghai, reaching Hong Kong on November 28th, whence I was to transfer to the P. & O. steamer *Ganges*, which had not yet arrived. The voyage had been pleasant throughout; good weather and fair winds prevailed. Bathing in a big tank on deck, tenpins, cricket, and other games helped to pass the time pleasantly, and the stops at some of the ports gave me an opportunity of renewing friendships made a year before, and when the ship reached her destination, I left her with regret.

Captain RINDER allowed my instruments to remain in the ship until the *Ganges* arrived, when they were transferred by a special lighter, thus saving much handling. Upon requesting the officers of the *Ganges* to handle the instruments carefully and "stow cool," the obliging chief officer had them placed over the

captain's cabin, covered with several tarpaulins and awnings — an ideal place for the hot tropical voyage ahead.

On December 2d, we sailed from Hong Kong for the last half of the voyage, and after the usual sightseeing of leaving port, I started for my stateroom. I say "my," for I had the exclusive use of a good deck room; but only a casual inspection established the fact that *our* stateroom was occupied jointly by myself and innumerable cockroaches and ants. That night, while he was holding court, I caught the king-cockroach, whose length measured over three inches. A Californian had presented me before sailing from home with a basket of choice apples, and, as one soon sickens of tropical fruit in the tropics, they were greatly appreciated; but I found that they were also highly esteemed by the rats on the *Ganges;* for, on account of the heat, cabin-doors were left open, and these permanent passengers invaded my room and left me only three out of about twenty-five, which was not a fair division. When I called the attention of the chief steward to it, he expressed unbounded astonishment — that the rats had left any at all! and it was painfully evident that I was no longer on the *Belgic.* On the voyage to Singapore, a sea came down the companionway and flooded the after-cabin, and nearly ruined the wardrobes of a San Francisco merchant, Mr. HENRY PAYOT, and his wife, and after this, a worse calamity followed; for the rats took and held possession for a couple of days, or until he hired the stewards to clear the room, to all of which the chief engineer facetiously remarked that no one was to blame, as "water and rats are the Queen's enemies"! Were it not for the kind and gentlemanly deck officers, I could not say a single good word for the *Ganges.*

A stop of a day at Singapore and some hours at Penang, gave plenty of time to visit the principal features of those places, and the three days at Colombo were used for a trip into the mountainous interior, to the old capital, Kandy, and the beautiful government botanical gardens at Peradeniya, where one may revel in the superabundance of tropical vegetation. Here every known spice in the world grows to perfection. Truly, Ceylon, "the pearl of India," is a land "where every prospect pleases," and the one land in the Far East in which I would have lingered longer. Another short run of a thousand miles, brought me to Bombay, fifty-two days from San Francisco, after a fine voyage of thirteen thousand miles.

Within an hour after reaching Bombay, I was about the

"King's business." I went at once to the customs office — that dreadful bugbear of travelers — to see just how I was to go about unwinding the usual red tape. Before leaving home, I had written to our Secretary of State, asking him to request our consul at Bombay to assist me in passing the instruments through the customs department with the least possible amount of unpacking. I asked the Indian official just what I must do, and, in turn, was asked the nature of the freight and my name. "Oh!" exclaimed the officer, "the government has passed a resolution about it, and you need not open anything!" This was not as surprising as it was gratifying; for I had hoped for something of the kind, and our consul, Major COMFORT, had arranged to have them passed without inspection. Even my personal baggage was not examined, my word that I had nothing dutiable being taken without question; the same courtesy being shown me in England on my way home, through the thoughtfulness of the Astronomer Royal, Dr. CHRISTIE, who was a fellow-passenger part of the voyage from Bombay.

Major COMFORT called upon me a few hours after the ship arrived, and all difficulties seemed to melt in his genial presence, each government official being, apparently, greatly interested in all things "eclipse-wise."

Where to establish the station was now a question of paramount importance. The farther south and west, the longer the time of totality; but near the coast there was a greater probability of clouded skies — not at all probable, however, anywhere.

The government representative, Professor NAEGAMVALA, suggested Indapur, where a bungalow was awaiting me; but finding that the instruments must be carried across a small river in a primitive ferry-boat, not large enough to carry a bullock-cart, I declined to take any risk whatever, and I finally decided upon Jeur, a "jungle" station on the line of the Great Indian Peninsular Railway.

For the first time I must lose sight of the instruments, and careful handling in transporting them to the interior was necessary. I called upon Mr. W. H. NICHOLSON, assistant traffic manager of the Great Indian Peninsular Railway, and it was a pleasure to see the cheerful interest he took in all my plans; he gave me the use of a "wagon" (car), no other freight being allowed in it, and a letter to agents instructing them to use great care in handling them, and to allow me to superintend loading,

... NEAR JHANSI, INDIA

and also directed that the car stand at Jeur without demurrage until I arrived, so that I could see to the unloading myself; thus every transfer was made in my presence from the observatory to the eclipse station. The company gave half rates to observers and their servants, and very low rates for instruments. This genial gentleman also assisted me on the day of the eclipse.

The instruments going by freight-train were forwarded at once, while I remained to employ a cook and interpreter, and to buy provisions and camp equipments; for all these must be procured in Bombay.

The bubonic plague now became a troublesome factor; the first three cooks I hired deserted when they found where I purposed going, as the plague had appeared only twenty miles away from the proposed camp, and subsequently came within seven miles, and was raging violently at Poona, the nearest large city. The proprietor of the hotel now came to my assistance, and said if I would wait two days he would get me "the best man in India." Of course, I waited for this remarkable person, and he arrived in due time. He was a native of Madras, with the English name of Caleb Phillip, but I knew him only as "Mustapha." He agreed to stand by me, plague or no plague; and as he said he could speak all the "longwidges," he could also act as interpreter. I do not know whether he was "the best man in India" or not, but I found him to be honest, industrious, and competent. He was a "Christian," although he indulged frequently in a mild type of profanity, and his general knowledge was invaluable to me, and I came to regard him more like a friend than a servant.

The station selected was in what is known as the "jungle," about six miles from Jeur railway station, near the little village of Wangi, in the Deccan, about two hundred and twenty miles southeasterly from Bombay, in the midst of a famine district — this being the second failure of crops in as many years, with plague east, west, and south of us. My camp — named Camp Pierson — was near one of the great irrigation wells, from which water was drawn daily for ten hours, with from two to four yoke of bullocks, and was shaded by some large babool and tamarind-trees, which added greatly to my comfort and capacity to work during the heat of the day.

Professor CAMPBELL, of the Lick Observatory-Crocker Expedition, occupied a station about two miles nearer Jeur, and I desire to express my gratitude to the Professor and the ladies

of his party for their hospitality while my own camp was being prepared, and for the many pleasant visits I received from them, almost daily.

The Indian Government furnished observers with tents, I having two, and subsequently four more for my European assistants, also, a policeman, and a sweeper (scavenger) who came to the camp twice daily.

I was assisted in all matters of selecting camp, employing help, etc., by Mr. DAJI DHONDEV PATANKAR, the Mamlatdar of Kermala, the highest official in that part of the country, and who, by instruction of the government, attended to the wants of observers, in person or through the village *patils* (officials). He was all-powerful in his district, and no one thought to question an order from the Mamlatdar. He established the price of eggs, milk, wood, and all such articles, and fixed the price of labor at *four cents* per day; but "Sahib CAMPBELL" had utterly demoralized the labor market by paying six cents, and I was expected to do, and did, likewise, although hundreds of men could have been employed for two or three cents a day — about all they were worth. The money spent by the various astronomical expeditions must have relieved the distress in many families; for so great were their necessities, that a large part of the population of the village was out daily gathering seeds from grass and weeds for food to keep soul and body together. One morning, before sunrise, a man, with his wife, mother, and three half-grown children, came into a field near the camp and worked all through the day until twilight. I bought the seed they gathered, which, after cleaning, just filled an eight-ounce bottle, and this was to have been their only food for the next twenty-four hours; and yet, with all their misery, they were kind to me, and brought me presents of pigeons, fruit, and wild honey, and were exceedingly grateful for a dozen packages of various kinds of vegetable seeds I took with me, as being likely to grow in a hot, dry climate, and which, if they can be successfully grown, will prove a greater blessing than any other thing I could have given them.

The work of unpacking, setting up, and adjusting instruments began at once, everything having arrived in perfect order; but I labored under many difficulties, expected and unexpected, materials not being obtainable. Lumber was the great drawback, none being nearer than Poona, a hundred miles away. Coal-oil boxes from the village "bazaar" were used freely as a substitute,

THE RIBBSON PHOTOGRAPHIC TELESCOPE AS MOUNTED IN INDIA.

for some sort of a daylight "dark-room" was necessary, and particular care was required to guard against the multitudinous insect life, especially the white ant, which is exceedingly destructive of wood. I repeatedly drenched the wood piers of the telescope and a liberal patch of ground all around them with coal-oil, which effectually protected them, and it required my best efforts to keep provisions, clothing, and everything eatable out of harm's way. Centipedes existed in great numbers, and I killed two snakes within ten feet of my tent, whose poisonous bite was rated at "death in six hours," and "death in twelve hours," etc., besides a "king" cobra of unusual size, while in company with the Mamlatdar, on the way from Jeur, which I carried to Professor CAMPBELL's camp in triumph. The howling of jackals prevented sleep for a few nights, but I soon became accustomed to their cry, while wild peafowls and monkeys furnished diversion during the day.

I received many visits from local officials, the village *patils* calling from two to five times daily, and were ever ready to assist me. Their principal business, however, was to furnish labor and keep beggars and curious natives away, who often came from miles away to see "Sahib" take his meals, and I seldom dined without interested observers. The cook, Mustapha, was next to the Mamlatdar himself, the most important man in the neighborhood, and did not hesitate to inflict corporal punishment with a stout stick, which he kept for the purpose, when outsiders crossed the line marking out the camp limits, or while "Sahib" was asleep. He took full charge of the domestic arrangements and was thoroughly efficient, and it seemed to me he knew everything, having traveled extensively in India.

The work of getting instruments into position and adjustment was pushed with all the vigor possible. The Pardee lens had not been tested for focus and other necessary adjustments before leaving, on account of the press of other duties, leaving much to do after arrival at the station, where it entailed much night-work, with only the most ignorant coolies, who wondered what all this fuss was about, for assistants. My average day's work during the thirty-seven days in camp, was not less than sixteen hours a day, and much of this under a fierce Indian sun that must be felt to be appreciated.

One condition, however, was very comforting; this same sun, rising and setting blazing hot every morning and evening, with-

out a cloud or fleck in the sky to mitigate the heat, gave promise of a clear sky on eclipse day, and the great source of anxiety on an eclipse expedition — the weather — was hardly considered. On one afternoon only, a slight filmy cloud appeared, but only for a few minutes, and during the entire stay in the Deccan with this exception, not a cloud was seen. The nights, however, were cold toward morning, the thermometer reading as low as forty-two degrees at six A. M., which seemed bitterly cold, and ninety-six the same day at eleven.

I had four English gentlemen for assistants on the day of the eclipse;— Major T. R. HARKNESS and Captain DUHAN, of the Royal Artillery; Mr. W. H. NICHOLSON (mentioned above) and Mr. W. H. HUSSEY, of the G. I. P. Railway. These gentlemen came from Bombay at their own expense, and with their retinue of servants strained my modest camp resources. The Indian servant, however, is always expected to take care of himself, and as it is the custom of foreigners in India to carry their own bedding, we — *i. e.* Mustapha and I — managed very nicely, and many times he came to me with plans for the entertainment of our distinguished guests, that he thought, if successfully carried out, would certainly dazzle them and reflect great credit on the expedition, and when I left India he had not yet ceased to congratulate himself and to brag about the general success of the manner in which we cared for our visitors.

My assistants reached camp on the morning of the day before the eclipse, and after thorough instruction in the parts they were to take, we began to practice, going through the programme many times that day, and after sunset, when the light was about the same as during the eclipse. Each man's part was carried out perfectly, and thus another source of anxiety was eliminated, my own part being least perfect, although I had rehearsed it on many days.

On the morning of the eclipse, the finishing touches were given, and everything tested and found perfect. I was ready. The government had brought a large body of police to the district to keep all but invited guests out of the camps; for, a great excursion from Bombay and other cities had brought many people to witness the great phenomenon. The police took complete charge of the roads at 6 A. M., and I had to send one of the policemen assigned to me on an errand, no private person being allowed to pass. They also prevented the usual howling and

THE PIERSON TELESCOPE, WITH THE PARDEE LENS AND TUBE ATTACHED.

brush-fires, "to scare the devil away," as the smoke might interfere with the work of the astronomers.

The day was perfect, and in perfect readiness we waited for the supreme moment, and at the given signal, in perfect silence, we again carried out the programme with machine-like precision— this time with powder and ball, so to speak. Two minutes!— and whatever the result, it was securely shut up in the ten plate-holders, carefully placed in my own tent to await development.

Only one word — "Look!" — was spoken, and that was agreed upon, so that all for about ten seconds might see the corona. While there was plenty of enthusiasm, there was no excitement or nervousness, and my confidence in my assistants was absolutely unbounded, and their work was simply perfect.

We watched the great shadow-cone as it swept northeasterly, the edges being distinctly visible; but I had no time to observe any of the usual phenomena, only noting that the light during totality was much greater than during the eclipse of January, 1889, which I believe was due to the great amount of dust in the atmosphere.

In the evening my assistants left me for their homes, and I began the task of developing. The weather conditions were exceedingly unfavorable; dust everywhere, the water too warm to develop, and no ice to be obtained, and nothing could be done except between midnight and dawn, when the water became cool enough.

Upon developing, I found the Pardee plates exquisitely sharp and perfect; but as they were made in the usual manner, they show no more than other good plates; while the Pierson plates, where the exposure was controlled by a new device, show the fine details, flames, and streamers at the Sun's limb, and an extension of the corona equal to two and one half diameters of the Moon, all upon the same plate, something never before accomplished, and giving almost perfection. My judgment, however, was at fault, as this was the first trial of the method; but I learned much concerning the brightness of the extreme inner corona (it has always been underrated), and the errors made can easily be corrected in future eclipses.

The plates — of which two were broken on the journey home, but have lost none of their scientific value — will be carefully studied this winter, and the full details of the apparatus and discussion of the results will be published separately.

On account of the extreme dryness of the air and the constant dabbling in photographic chemicals, my hands were in a dreadful condition, and pained me so that sleep was almost impossible, and the all-day and nearly all-night work of the last ten days reminded me of some misguided friends at home. who had never been with an eclipse expedition, and who "hoped I'd have a nice time"! In seven days after the eclipse I finished the work, and with a string of bullock-carts, and followed by half the population of Wangi, I started for the railway station and civilization, tanned beyond recognition, and with hands swollen and calloused like a laborer's.

The Mamlatdar drove the villagers back, but about a dozen begged to be allowed to go with "Sahib" to the station, and, at my request, he allowed them to go. I parted from some of them with regret, and shall long remember this little Indian village and its dusky citizens.

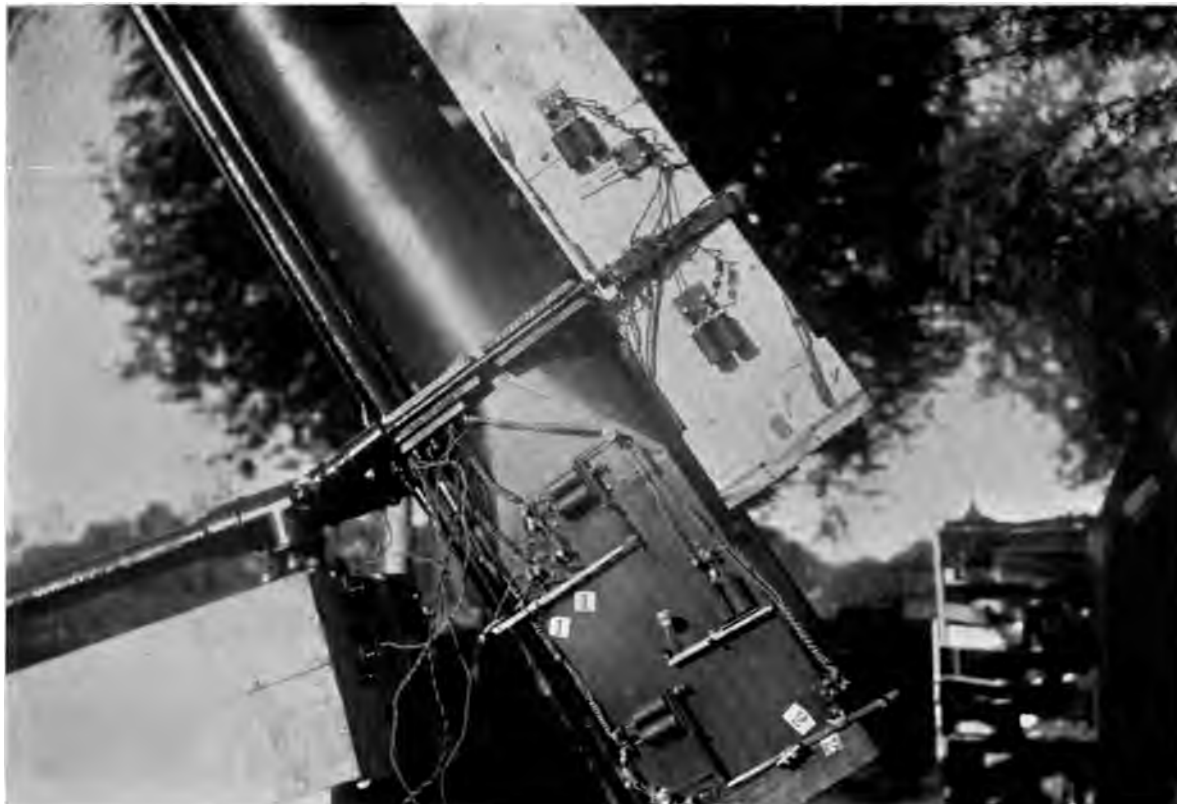
Again my friend Mr. NICHOLSON placed me under obligations by telegraphing permission to ride over the Ghauts Mountains on the engine, in order that I might see to advantage that marvelous piece of railway, of twenty miles in length, which required five and a half years to build!

The instruments came home by way of China, while I continued my journey — ever westward — *via* Aden, Suez Canal, and Europe, reaching home on April 16th, after an absence of nearly six months.

Among the experiences of the return journey were a quarantine at Ain Musa (Moses's Wells) in Arabia, on account of the bubonic plague in Bombay, and a short visit to Egypt and Palestine; but, as a friend has recently said in this journal, this "is not an astronomical story."

In closing, I wish to express my appreciation of the help received from Major COMFORT, Major HARKNESS, Captain DUHAN, Mr. NICHOLSON, Mr. HUSSEY, and other friends in far-away India — not forgetting my faithful Mustapha — who did so much for me, and all in their power for the success of the expedition.

OAKLAND, CAL., November, 1898.



THE "EYE-END" OF THE PIERSON TELESCOPE.

THE DEVELOPMENT OF PHOTOGRAPHY IN ASTRONOMY.*

By EDWARD E. BARNARD.

At the beginning of the work of this Association, the great discovery of making pictures by the natural light of the Sun had just been made, and while it aroused a wide-spread interest all over the world at that time, there were few who dreamed of the great future value of photography in the arts and sciences. . . . It is especially gratifying to Americans that the first efforts to utilize the new discovery for the benefit of astronomy were made in this country.

Within less than one year from the announcement of DAGUERRE'S discovery, in March of 1840, Dr. JOHN W. DRAPER, of New York City, had succeeded in getting pictures of the Moon, which, though not very good, foreshadowed the possibilities of lunar photography. Five years later, the Harvard College Observatory may be said to have commenced its remarkable career of astronomical photography, when BOND, with the aid of Messrs. WHIPPLE and BLACK, of Boston, succeeded in getting still better pictures of the Moon with the 15-inch refractor. The next successes were due to the English astronomers, DANCER and DE LA RUE. The latter using a 13-inch speculum, without clock-work, made the most important of the early efforts at lunar photography.

In 1860, the subject was again taken up in America, this time by Dr. HENRY DRAPER, who, with a 15½-inch reflector of his own construction, secured photographs of the Moon superior to any previously made. These pictures of the Moon were the best taken until LEWIS M. RUTHERFORD began his remarkable work, about 1865. Using an 11-inch refractor, constructed under his immediate supervision—the first telescope corrected especially for the photographic rays—RUTHERFORD secured photographs of the Moon that have only been excelled in the past few years with the

* Professor BARNARD'S interesting and important address, given before Section A, Mathematics and Astronomy, of the American Association for the Advancement of Science, was to have been printed in full in our October issue; but owing to circumstances over which neither Professor BARNARD nor the Publication Committee had any control, the address was not received in time. As it has since been printed in full in *Science* (Sept., 1898,) and *Popular Astronomy* (Oct., 1898.), we reprint here only a comparatively brief abstract.

aid of such instruments as the 36-inch refractor of the Lick Observatory and the equatorial coudé at Paris.

But what is shown by the best lunar photographs has not yet approached that which can be seen with a good telescope of very moderate size. The minute details are at present beyond the reach of photography.

The first picture of the Sun seems to have been made on a daguerreotype plate by FIZEAU and FOUCAULT, in 1845. During the total eclipse of the Sun on July 21, 1851, a daguerreotype was secured with the Königsberg heliometer, by Dr. BUSCH, which appears to have been the first photographic representation of the corona. Photographs of more or less interest were secured at subsequent eclipses; but the first to represent the corona with real success was obtained at the eclipse of December 22, 1870, when the corona was shown on the plate to a distance of about half a degree from the Moon's limb. The eclipse of 1871 was still more successfully photographed, and an excellent representation of the corona, full of beautiful details, was secured.

All these pictures were made with the wet process; for the dry plate was not successfully used until about 1876, and it was five or six years later before it became generally useful or at all reliable.

In 1878, extensive preparations were made to observe the eclipse of July 29th of that year. Photography played an important part, though each astronomer also made the customary drawings of the corona. The comparison of the drawings with each other and with the photographs showed the utter inability of the average astronomer to sketch or draw, under the attending conditions of a total eclipse, what he really saw.

The closing of the year 1888 and the opening of 1889 brought one of the most important eclipses that had yet occurred from a photographic standpoint. Certainly no previous eclipse, nor any since, so far as that is concerned, was photographed by so many different persons, and with such a varied assortment of cameras, telescopes, etc. The path of this eclipse lay across Nevada and California, and every photographer, amateur or professional, near the line of totality, took part in the work. The amateur photographers of San Francisco and Oakland banded together under the leadership of Mr. CHARLES BURCKHALTER and photographed the eclipse in a systematic manner, the result being a most excellent collection of negatives of the corona. In some of these pictures the coronal streamers were carried to a far greater extent

than at any previous eclipse; especially was this so in the photographs made by two of the amateur photographers, Messrs. LOWDEN and IRELAND. At this eclipse the lot fell to the writer to make the photographs for the Lick Observatory. But at this time the observatory had no instruments suitable for the work. To secure as large an image as possible with the poor equipment at hand, a 3½-inch visual objective, by ALVAN CLARK, was selected. This lens, after being reduced to one and three fourths of an inch in diameter and mounted in an oblong box, fastened to a polar axis driven by the clockwork belonging to the 12-inch equatorial, was found to give a fairly good photographic image. With this and two small photographic cameras nine negatives of the corona were secured. The best of these was one made with the CLARK visual objective. By extreme care in development, this negative not only showed the exquisite polar systems of streamers and the details of the corona close to the Moon, but also carried the coronal extensions a great distance along the ecliptic. This was by far the most successful eclipse, photographically, of any that had yet been observed, and forever set aside as worthless the crude and wholly unreliable free-hand sketches and drawings previously depended upon.

The eclipse of 1893 was successfully photographed in Brazil, Africa, and Chile. Professor SCHAEBERLE made arrangements for the photography of the corona on a large scale, and at Mina Bronces, Chile, secured a fine series of photographs. The image was formed by a stationary lens five inches in diameter, and with a focal length of forty feet, upon a large sensitive plate, which was moved by clockwork, to counteract the Sun's motion during the few minutes of the eclipse. In these pictures the image of the Sun was on such a large scale that the coronal details could be very accurately studied.

During the solar eclipse of 1896 the sky was cloudy at nearly all the stations, but a few photographs were secured. The most important one was that of the flash spectrum or the momentary reversal of the FRAUNHOFER lines which occurs just at the beginning and at the end of totality. This important picture, a triumph for photography, was made by WILLIAM SHACKLETON, a young Englishman, who, at the right instant, exposed a plate which caught for the first time the fugitive bright lines, which are only visible for about a second. At the recent eclipse, January 22, 1898, the photograph of the flash spectrum was repeated by many observers.

There is no question but JANNSEN, of Meudon, succeeded, many years ago, in making the best photographs of portions of the Sun's surface that have yet been made. This astronomer has always used the old wet-plate process, which seems to give the best results in solar work. One peculiar feature of these photographs is the frequent presence of blurred regions, in striking contrast to the generally exquisite sharpness of the granular surface. These disturbed regions are believed by JANNSEN to be due to actual disturbances on the Sun's surface and therefore to be true phenomena of the Sun. I have always had the impression that they are simply due to the presence of small areas of bad seeing which are passing at the moment of exposure; that is, they are the effects of small local disturbances in our own air, such as every visual observer is familiar with in night work. Doubtless, M. JANNSEN has long ago decided this question; but if so, it has escaped my notice.

Daily photographs of the solar surface are made at a number of observatories, principally at Greenwich, Kew, and in India, and, of late years, at the Lick Observatory. Thus a valuable record is kept of the changes taking place on the solar surface. One thing that this repeated and constant photographing of the Sun has proved, is the non-existence of the so-called intra-mercurial planets, which before the days of photography were so frequently seen transiting the Sun. Just as the photographic plate has accomplished this, so will it finally, when it has attained more perfection in dealing with the planets, show that many of the strange features ascribed to the surfaces of some of them do not exist.

At the eclipse of 1868, JANNSEN and LOCKYER found that the visibility of the solar prominences did not necessarily depend upon a total eclipse of the Sun; they found that by the aid of the spectroscope they could be seen at any time. This suggested to Professor YOUNG the idea that they might also be photographed at any time; and in 1870 he met with partial success in such an attempt. To photograph those objects successfully, however, required the invention of a new instrument, the essential features of which are two slits (very narrow, compared with the height of the prominences), moving in perfect unison — one placed across the Sun in front of the grating or prism, the other in front of the photographic plate — and adjusted perfectly to the spectral line of the prominence, so as to exclude all light save that emitted by the prominence itself. By the gradual motion of these two slits,

the entire object is successively uncovered, and an exact photograph secured of it. To make one of these pictures takes several minutes of exposure. This extremely ingenious device owes its existence to the inventive genius of Professor HALE, who devised and built the first instrument of this kind, and secured the first actual spectroscopic photograph of the prominences. This was in 1891. By a further ingenious extension of the possibilities of the instrument, it is made to move across the entire Sun's disc, thus securing every prominence at that time visible. By hiding the Sun's image by an occulting disc in the first sweep, and then making a second similar but more rapid sweep with the Sun's image uncovered, a complete picture of the Sun, with all its surroundings, with the exception of the corona, is secured. This is the method employed by Professor HALE in his work. These pictures, however, show only those features which are due to hydrogen or calcium, and the solar surface thus appears very different from the telescopic view of it.

From the first photograph of a star, by BOND, in 1850, to the present time, stellar photography has gradually risen to a prominence as remarkable as it is important. The real increase of importance, however, has occurred within the past ten or fifteen years, since the successful introduction of the very rapid dry plate. The wet, or collodion, process was poorly adapted to the photography of the stars, and of no use whatever for comets and nebulæ.

Notwithstanding this, the photographs of the star-clusters, etc., of the southern skies obtained under the direction of GOULD with an 11-inch photographic refractor, by the wet process, were of the highest value, and showed upon measurement a striking agreement in accuracy with visual work. The same can be said of RUTHERFORD'S photographs of the *Pleiades*, *Præsepe*, etc., which were made prior to Dr. GOULD'S, and which were the first photographs of this kind.

Attracted by its great brilliancy, Dr. GILL, at the Cape of Good Hope, with the aid of a local photographer, secured a fine series of photographs, with dry plates, of the great comet of 1882. When these photographs reached the northern hemisphere, they attracted a great deal of attention, not only on account of the comet itself, but also from the number of stars that were impressed upon the plates. The idea at once occurred to the HENRY Brothers, who were making a chart of the stars along the ecliptic in their search for asteroids, that they could use this wonderful

process in their work. To this simple incident the active application of stellar photography of to-day is due. They began at once the construction, with their own hands, of a suitable photographic telescope of thirteen and a half inches in diameter. This instrument was soon finished, and the astronomical world knows to-day what wonderful results these men produced with it.

Singularly enough, the photographic plate not only did away with the necessity of making charts by eye and hand to facilitate the discovery of asteroids, but it also did away with the necessity of the charts themselves for that purpose; for the little planet now registers its own discovery, by leaving a short trail on the photographic plate. The first of these photographic discoveries of asteroids was made by Dr. MAX WOLF, in 1892. They are now found wholesale in this manner.

It was the success of the HENRY Brothers' work that led to the International Astro-Photographic Congress which met in Paris in 1886. The Congress adopted the HENRY Brothers' lens as a model for the instruments to be used, and the work of this great undertaking was based on that of the HENRY Brothers.

Perhaps the most unpromising subject for the photographic plate to deal with was the nebulæ, and yet it is in this direction that photographic astronomy has most decidedly excelled. From September, 1880, when Dr. HENRY DRAPER secured the first nebular photograph the work of DRAPER, JANNSEN, COMMON, ROBERTS, and others has steadily advanced our knowledge of the structure and true outlines of these wonderful objects, revealing details — and even, as in the case of the *Pleiades*, streams and masses of nebulosity beyond the reach of existing visual telescopes.

While it is absolutely necessary to use a considerable photographic telescope for the accurate registration of star-positions, etc., where measures of precision are required, there are a great number of objects in the sky which are not necessarily subject to measurement, and which for their greatest value require a simple pictorial representation. The Milky Way, one of the most beautiful, and certainly the most stupendous, of the celestial features, is not susceptible of accurate measurement. Nor would the work be of any very great importance could it be accomplished as a whole. What is required in the study of this wonderful object — this mighty universe of stars — is something that

will increase the penetration of our vision, and at the same time give us a certain amount of accuracy of position with a large field of view, so that we may study its peculiarities of structure in detail, and at the same time closely locate these details with reference to the whole; and thus, by finally putting structure and detail together, form a comprehensive idea, not only of the details themselves, but also of the relation of these features to each other. The long-focus telescope with a very limited field is not capable of dealing with the Milky Way in the manner stated. Its structural details are very large, far larger in general than is the field of view of the ordinary photographic telescope, and vastly greater than that of a powerful visual telescope. We want, therefore, a short-focus instrument, one capable not only of taking in a wide part of the sky, but also of giving a brilliant image, or, in other words, the reduction of the large details to a smaller scale with a correspondingly great increase of effective light-power. These conditions exist in the large portrait-lenses which were needed in the early days of photography to reduce the exposure time by collecting a great quantity of light from the object, and which in these days of rapid dry plates are no longer required for portrait work. Taking in some ten or twelve degrees of the sky, these lenses are specially suitable for photographing large surfaces such as are presented by the Milky Way.

This subject was taken up by the writer in the first part of 1889, at the Lick Observatory, with a large 6-inch portrait-lens of thirty-one inches focus, and with it was inaugurated the photography of the Milky Way. The first picture to show the real structure of the Milky Way was made in 1889, with this instrument. In the following years a large series of photographs of those portions of the Milky Way seen from the northern hemisphere was made. The work with similar instruments was next taken up by Dr. MAX WOLF, in Germany, who has also succeeded in making excellent pictures of the Milky Way. Mr. RUSSEL, of Sydney, New South Wales, has also photographed portions of the southern part of the Milky Way with a large portrait-lens. Those who have seen some of the Milky Way photographs taken with the regular astro-photographic telescope, or who have tried to make out its complex structure with a visual telescope, must be struck with the great beauty of a photograph made with one of these short-focus portrait-lenses. The extraordinary complexity of structure of the Milky Way is brought

out with marvelous beauty of detail, and the peculiarities of its different portions can be traced and connected in the different photographs, which thus afford the most direct means for studying every feature of structure and detail. These pictures show many peculiarities which must materially alter our ideas of the constitution and structure of the Milky Way. Some of them show strong evidence that the general body of the Milky Way may be made up of small stars which are not at all comparable with our Sun in dimensions. This is especially shown in the region of the star ρ *Ophiuchi*. Many parts of the Milky Way appear to be comparatively thin sheetings of stars, with relatively no very great depth; for it is not possible otherwise to explain the black holes and rifts shown in them. One of the most important revelations made by the portrait-lens in connection with the Milky Way, is the presence in it of very diffused nebulous matter, apparently freely mixed with the groundwork of stars, and seemingly showing no definite tendency to condensation about the individual stars. These photographic nebulosities of the Milky Way are apparently of a different nature from the ordinary nebulæ of the sky, since they are extraordinarily large, diffused, and but feebly luminous. These nebulous regions seem to be peculiar to the Milky Way and its vicinity, and are certainly in some way physically connected with it. It will be in the study by photography of such regions that we shall finally clear away some of the mysteries of the Milky Way. These masses of diffused nebulosity mainly affect regions of the sky in *Scorpio*, *Cygnus*, *Cepheus*, *Perseus*, and *Monoceros*. I believe it to be true that no other form of telescope but the old-time portrait-lens, or similar combination, is capable of dealing with these extraordinary objects.

It was not until the study of the phenomona of comet-tails with portrait-lenses that we knew anything of the strange phenomena shown by them. It may be said that our knowledge of the extremely rapid transformations in the tails of comets dates from the photographs of SWIFT'S Comet of 1892, taken at the Lick Observatory with the lens previously mentioned, and by Professor PICKERING, at Arequipa, with a similar instrument. While only an insignificant affair visually, and but fairly visible to the naked eye, SWIFT'S Comet showed upon the photographic plates the most extraordinary and rapid transformations yet seen in any comet. One day its tail would be separated into at least a dozen individual streams, and the next present only two broad stream-

ers, which a day later had again separated into numerous strands, with a great mass, apparently a secondary comet, appearing some distance back of the head in the main tail, with a system of tails of its own. This remarkable appearance was the first known of its kind, though it was repeated in the photographs of RORDAME's Comet of 1893, made by Professor HUSSEY. These peculiar phenomena seem to be a production of the comet itself—a result of the forces at work in the head of the comet.

The photographs of BROOKS's Comet of 1893, also secured with the WILLARD lens, showed such an extraordinary condition of change and distortion in the tail as to suggest some outside influence, such as the probable collision of the tail with some resisting medium, possibly a stream of meteors, such as we know exist in space. The long series of photographs obtained of this comet frequently showed great masses of cometary matter drifting away into space, probably to become meteor swarms. One of the pictures showed the tail of the comet streaming irregularly, as if beating against a resisting medium, and sharply bent at right angles near the end, as if at that point it encountered a stronger current of resistance. All of these wonderful phenomena would have been unknown to astronomers had it not been for these photographs, and the comet, instead of proving to be one of the most remarkable on record, would have passed without special notice. Though these phenomena were so conspicuously shown, scarcely any trace of the disturbance was visible with the telescope. On account of the apparent insignificance of the comet visually, no photographs were made of it elsewhere during its active period.

In the matter of discovery, the photographic plate has accomplished a very great amount in certain directions. In spectroscopic work, it has a field singularly suited to display its possibilities, and the most important researches in this direction are now conducted by this means. The discovery of variable stars by photography can be compared with the wholesale business in commercial circles, because of the great numbers that are found on the various plates.

In the discovery of nebulæ and asteroids the photographic plate has done a great work, which is still being carried on.

Up to the present time but two comets have been discovered by photography. The first of these was discovered on a photographic plate taken by the writer on October 12, 1892, with the 6-inch WILLARD lens of the Lick Observatory, and was subse-

quently verified visually, and observed at different observatories. The second was discovered at the same observatory by Mr. CODDINGTON, with the same instrument, in July, 1898.

There are very few departments of astronomy where photography has not taken a prominent, if not a commanding, position. It is probable, however, that it will never take the place of the micrometer in the observation of close double stars and similar objects, and in this direction the micrometer of BURNHAM will perhaps never be displaced. The photography of the surface features of the planets is in an almost hopeless condition at present, yet much can be expected in this direction when an increased sensitiveness of the plates has been secured.

It is impossible within the limits of this address to give more than a general, and at best incomplete, sketch of the rise and progress of photography in the various lines of astronomical research. To those who have kept pace with these rapid strides in the last twenty years, this brief history will seem imperfect, and perhaps of little interest. Many applications of the photographic art, and many valuable results have necessarily been omitted. But few of the names of those prominently identified with this subject have been mentioned, and but little of their work even alluded to. A volume of no small dimensions would be necessary to give a complete history of the development of photography in the many directions in which it has been applied to astronomy. The time to do this has not yet come. Progress has been so rapid and far-reaching that its history, however complete and exhaustive, a year later requires to be rewritten; and there is no reason for supposing that the end, or even the beginning of the end, has been reached. With new materials, and new methods, and new workers, who will profit by the experience and results gained by those who have in our time accomplished so much, we may expect for the new century far greater results than those briefly recorded here.

THE SURFACE OF THE SUN.

BY ROSE O'HALLORAN.

The following data, obtained from records of the condition of the solar surface as observed with a four-inch telescope, seemed to indicate the near approach of the sun-spot minimum.

Between October 17, 1897, and March 18, 1898, the Sun was observed on one hundred and twenty-six days, during which thirty spots appeared on the disc, three of which were of considerable size, having nuclei that measured from 10,000 to 20,000 miles length.

The various durations of these thirty markings caused the Sun to present a spotted appearance on ninety-eight days, which were interspersed with intervals of unspottedness amounting to twenty-eight days, the longest interval being fourteen days, in the latter half of October, 1897. During a succeeding period of equal length, dating from March 18th to August 16th, in the present year, observations were taken on one hundred and thirteen days, seventy-three of which revealed a state of activity due to the coming and duration of nineteen spots. In three cases the nuclei measured about 10,000 miles, and a nucleus double that length was conspicuous in the beginning of August. On forty

SUN-SPOT, SEPTEMBER 9TH, NOON.

days the disc was an unbroken white tract, sixteen consecutive days of unspottedness having occurred in April, while the remainder were distributed in much smaller divisions. In these comparative data the term *spot* is used not only to denote single markings far apart from others, but also groups in which the components are sufficiently close to be regarded as the result of one disturbance. The cloudy days are indeterminable factors; but as in this Californian climate the Sun is rarely obscured for many consecutive days, it is not probable that cloudiness changes the result materially, unless there be only a trifling difference in the compared data.

Three small spots appeared between August 16th and September 2d, and on the morning of the latter date the symmetry of the southeast limb was noticeably impaired by the advent of an enormous spot, about 51,000 miles in length. On September 4th,

two almost imperceptible markings appeared adjacent to its eastern side, and on the 7th commenced to develop, forming large penumbral tracts with several small nuclei. The nearest spread into connection with the large spot, and the group then extended over an area 140,000 miles long when on the center of the disc. Having observed the Sun for the past eight years, and preserved drawings of the principal spots, comparison shows that during that period it has been equaled only by those of February, 1892, and August, 1893, in compactness and extent. Though it seemed lower on the disc, owing to the position of the plane of the solar equator on those days, measurement placed it between south heliographic latitude 8° and 15°.

SUN-SPOT, SEPTEMBER 3D, 2:30 P.M.

It may have been the development of a very small spot that commenced its existence towards the center of the disc on August 11th within the same latitude; otherwise, it cannot be traced as the continuance of any previous disturbance, and must have formed on the unseen surface in the latter half of August.

The final chapter in the career of this unseasonable solar storm is its return in due time on September 28th in the form of two small spots with dark nuclei. On the 30th one of much larger size followed them, but it could not be classed as a remnant of the giant storm, though its position was suggestive of a common origin.

SAN FRANCISCO, October 13, 1898.

THE TEMPERATURE OF THE SUN. II.

BY PROF. DR. J. SCHEINER.

[Translated from the German in *Himmel und Erde*, by FREDERICK H. SEARES.]

It is a fundamental law of all exact investigation that the investigator should not be satisfied with the derivation of an important result in the most direct way alone, but that he should strive by other means, or by indirect methods, which, under certain circumstances may be very complicated, to arrive at the same result. Only when this has been done, where the same end has been reached by following different lines of thought, can the result be said to have been established. Frequently it happens that, in consequence of the nature of the problem, the methods

which can be applied do not lead to definite numerical values; in these cases the investigator must be satisfied with a result which sets only an upper or a lower limit, or perhaps places the desired result within two limiting values. Such is the case in the problem we are considering; we can by the use of indirect methods obtain only an approximate confirmation of the value of the solar temperature given by the direct method.

We shall now examine these so-called indirect methods, and discuss those possessing the greatest similarity with the direct method, inasmuch as with them the solar radiation is directly involved.

It is a fact known to every one that the small image of the Sun formed by a burning-glass or burning-mirror possesses a very high temperature. With even a small lens one can almost instantly ignite bits of wood and paper. A number of years ago CERASKI, in Moscow, with a very perfect burning-mirror of one meter diameter, carried out a most interesting series of experiments. He succeeded in melting, burning, and vaporizing in the focus of his mirror all of the substances accessible to him, and his estimate of 3,500° for the temperature in the focus appears not unreasonable. From this it follows directly that the solar temperature must be higher than 3,500°; for there exists a well-founded law of the mechanical theory of heat, to the effect that of two bodies the colder can never increase the temperature of the warmer; on the contrary, the opposite phenomenon always occurs. Consequently, no crowding together of the solar rays by a burning-glass can create a temperature greater than that of the Sun; otherwise, we should have the relatively cold Sun increasing the heat of the relatively hotter focus. In fact, heat is lost in the transfer through absorption and imperfections in the glass or mirror, so that the temperature of the focal point must always be lower than that of the solar surface. This conclusion, not so easily to be passed by, can be made more plausible by the following considerations: A condensation of the rays by a lens or mirror is equivalent to an increase in the apparent extent of the radiating body (the Sun), or, to a diminution in its distance. Under the most favorable circumstances, the equivalent distance of the real Sun corresponding to the focal temperature would be zero, which means that at most the focal temperature can only equal the solar temperature, never exceed it.

In order to obtain a comparison with other temperatures

CERASKI measured with the same mirror the temperature increase in the focus produced by the radiation of an electric arc of the same apparent diameter as the Sun. He found an amount varying from 100° to 105°. From the enormous difference, as compared with the action of the solar radiation, CERASKI concluded that the solar temperature must be far higher than 5,000°. This conclusion is correct. If we apply STEFAN'S law to CERASKI'S data we obtain a temperature of over 3,000,000°. This number so flatly contradicts the results of the previously discussed direct methods that we can at once declare that some factor has been overlooked in the investigation; apparently, it arises from the use of the electric arc as the radiation source, for considerable difficulties are met in the arrangements of the experiment.

The first to attempt to determine the solar temperature from a purely theoretical standpoint was ZÖLLNER. He assumed the protuberances to be streams of gas from the center of the Sun generated by great differences of pressure; then, assuming further the laws governing gases in their terrestrial relations to be valid for the solar conditions, he was able to derive a value for the temperature of the solar surface which he considered to be liquid. For this surface he found the temperature 13,230°, with a rapid increase for increasing depths below the surface. For a point whose depth is one fortieth the solar radius the corresponding temperature would be 1,112,000°.

Later ZÖLLNER used another method, somewhat more free from assumptions, which by ingenious considerations afforded for the uppermost limits of the photosphere the value 61,350°. At the present time ZÖLLNER'S investigations have only an historical interest.

Upon the assumption that the Sun glows as a ball of gas, that the photosphere therefore does not to any extent radiate heat and light arising from suspended glowing particles, EBERT has given a determination of the solar temperature. He considers the radiation to be electro-magnetic in its nature, and although it is not possible to give here the details of his discussion, the final value obtained is 40,000°; but it is to be remarked that this number corresponds not to the uppermost limit of the photosphere, but to a deeper layer, where the gases are under much greater pressure.

Free from all assumptions as to the constitution of the Sun, and depending only upon the validity of KIRCHHOFF'S law, is a

determination of the solar temperature, and at the same time of that of the fixed stars, made by the writer several years ago. It rests upon a remarkable relation existing between two magnesium lines in the blue part of the spectrum. The first of these lines appears strong in all the spectra of the stars of Class I; in the spectra of Class II, to which our Sun belongs, it is weak; and in those of Class III it appears to be wanting. In the electric spark of magnesium the line is strong, but, on the other hand, it does not appear either in the electric arc or in burning magnesium. Remarkably enough, the second line presents the opposite phenomena, both in the stars and in the laboratory. The favorable circumstance that two lines belonging to the same substance should show an opposite behavior proves at once that the phenomena presented by these lines in the stars depend only upon the temperature, and not upon the pressure or density of the gases in the atmosphere. One thus arrives at the conclusion that the temperature of the photospheres of the stars of Class II (Sun) is somewhat higher than that of the electric arc, but considerably lower than that of the electric spark. As a lower limit we may assume 5,000°; the upper limit is more uncertain, but can scarcely exceed 10,000°.

From the preceding considerations we have attained information concerning the temperature conditions of the Sun which will afford us the means of deriving other conclusions, giving an interesting insight into the arrangements of our solar system. We have found, according to our conceptions, that the temperature of the solar surface is very high, although not nearly so high as was supposed a few decades ago. We have incidentally determined a very important number, namely, the amount of energy conveyed by the Sun through its radiation in one minute to an area of one square centimeter at a distance from the Sun equal to the Earth's distance. This latter number (3.75 calories) enables us to determine the total amount of energy radiated, and therefore the amount lost, by the Sun. It is clear that we have only to multiply the solar constant thus found by the total number of square centimeters in the surface of a sphere whose radius is the Earth's distance from the Sun, in order to obtain the amount of energy lost during each minute. A more convenient unit is the total loss for a year, which is given by multiplying the above product by the number of minutes in a

for Europe by a change in the course of the Gulf Stream, through volcanic upheavals — perhaps by the breaking through of the Mexican Gulf to the Pacific Ocean beyond.

All considerations of this kind indicate that a reduction in the solar temperature, which must show in the radiation amount, has not taken place during the past few thousand years, and it is therefore clear that there must be active forces which nearly, if not entirely equalize the temperature decrease due to radiation. This equalization may be thought of in two ways: Either there must, by some means, be conducted to the Sun energy from without, so that neither a decrease in temperature nor a diminution in the amount of heat can arise, or there must be, in consequence of internal processes, a maintenance of temperature, not of energy, however. In the latter case, the time during which the equalization can continue is limited, since the internal energy must at last become exhausted; but in the first case the present temperature may be maintained indefinitely, since the inflow of external energy may, on account of the infinity of the universe, be inexhaustible.

We must now examine the means by which energy might be conveyed to the Sun from without. First, we may think of the radiation received by the Sun from the fixed stars, which must send out streams of energy similarly to the Sun itself. The radiation of the fixed stars, even of the brightest, is so slight that its existence has so far been scarcely detected, even with the most sensitive apparatus, although one may think that the total amount received by an enormous sphere like the Sun would not be inconsiderable. A simple reflection, however, shows the impossibility of such an explanation. Upon the above hypothesis, our Earth must be as intensively heated by the stellar radiation as the Sun, and its temperature must be approximately equal to that of the Sun.

A second conceivable means of conveying energy to the Sun, which at the same time would increase its mass, is the bombardment of its surface by meteoric bodies. On account of the ordinarily great velocity of these bodies their kinetic energy and the equivalent heat energy is very great, in spite of their small mass. Formerly great importance was attributed to this means of transference of energy, and its effect was computed, assuming for the number of bombarding meteors a quantity corresponding to the number obtaining for the Earth. This procedure is unjustifiable,

however, since it involves the assumption that space is filled to the same extent throughout with meteoric material, which is without doubt incorrect. Of the minute particles scattered throughout the universe which come within the sphere of the Sun's attraction, evidently only an infinitesimal part actually fall upon the Sun; an immeasurably greater number are drawn into closed orbits, so that during the immense periods of time which have elapsed the Sun has gradually become surrounded by a shell of meteoric particles, which, beyond question, are here much more densely packed than in the space without. The shooting-stars and meteors of the Earth depend upon the density of this shell; those of the Sun, only upon the meteoric density of space in general. In this consideration we have omitted the possibility that a great part of the meteors came not from space without, but that they belonged originally to the solar system.

It will be best to compute from the energy loss of the Sun the mass of meteoric particles necessary for the reparation of this loss. A body coming within the reach of the Sun's attraction, and falling upon its surface, attains at the instant of striking a velocity of 607 kilometers per second. In order now to cover an annual loss of 55×10^{31} calories, with this maximum velocity there would be required a mass of 12×10^{18} kilograms, which, if we assign to meteoric masses the specific gravity of iron, of which they are largely constituted, would occupy a space of 1.6×10^{15} cubic meters—a volume equal to that of a sphere of 48 kilometers radius. It is a matter of choice, rather than of scientific discussion, as to whether or not one accepts the probability of the addition of such an enormous mass to the Sun. Such a supposition is not in conflict with the results of observation, for the annual increase in mass is only $\frac{1}{100,000,000,000}$ of the solar mass, a quantity which can have no effect on the planetary motions discoverable by our present observational methods.

On account of the greater meteoric density in the neighborhood of the Earth, a relatively far greater number must fall upon its surface, and we can therefore accept unhesitatingly YOUNG's conclusion, which states: If meteoric masses were really present in such great numbers, they would fall upon the Earth much more frequently than they actually do. Indeed, the Earth would be struck by such numbers that its temperature would be raised far above the boiling-point of water.

In the beginning of 1880 appeared a theory by WILLIAM

SIEMENS, which at that time aroused great interest, and according to which the energy of the Sun is not dissipated into space, but conducted back to the Sun again.

The idea underlying this theory arises more from philosophical exigencies than from scientific considerations — from the repugnance to the human mind of the knowledge that the solar energy is uselessly squandered; only $\frac{1}{225,000,000}$ of the same finally reaching the planets. Seldom it is, however, that a scientific attempt arising from the influence of the human spirit, or from fancy, becomes of real value. SIEMENS's theory is to-day placed *ad acta*, but deserves, however, upon historical grounds, and on account of its ingenious line of reasoning which is not to be denied, a brief presentation.

SIEMENS assumed space to be filled with extraordinarily rare gases, such as hydrogen, oxygen, nitrogen, and carbon compounds and solid particles of cosmic dust. Each planet attracts these gases and forms about itself an atmosphere, the lower layers of which contain for the most part the heavier gases. The entire solar system is surrounded by a similar atmosphere, whose bulk occupies the space between the planetary atmospheres and extends out into the universe beyond. The rarification is always assumed to be so great that no appreciable influence of friction appears in the motions of the planets.

The rotation of the Sun acts through friction in this envelope like a fan; the gases at the poles are sucked down and move toward the equator, where they are thrown out into space again. Upon approach to the Sun the very rare gases become gradually condensed and thereby heated; upon contact with the atmosphere combustion takes place, and a large amount of heat is generated, which serves to replenish the solar energy. The products of combustion are thrown outward again at the equator. The most important point in the SIEMENS theory is that these products become again regenerated through the energy of the solar radiation. The radiant energy is thereby used, and it cannot continue to pass on into space. The justification of such an assumption SIEMENS derives from experiments by TYNDALL, according to which radiating heat is very powerfully absorbed by water-vapor and other combinations upon the dissociation of the constituent gases. The regenerated gases are drawn back to the poles by the fan-like action of the Sun, are then again burned, and so on throughout an endless repetition.

The SIEMENS theory has become involved in an extensive

controversy, and a large number of objections have been raised against it, which, moreover, as must be added, have been partially refuted by SIEMENS. We will here bring forward a single argument against the theory. If the energy loss of the Sun is for the most part to be made good, then there must be constantly directed upon the Sun a stream of energy corresponding in a sense to that which is continually radiated outward. Of the latter we have ample evidence — it is the cause of our existence; but of the former there is no trace. This is the inexplicable contradiction between the SIEMENS theory and the facts of experience.

We are thus led to the unavoidable conclusion that the solar energy is really radiated outward into infinite space, and that it receives no important compensation from without. On the other hand, we have shown with great certainty that up to the present time no considerable reduction in the solar temperature has occurred. We must therefore examine the second hypothesis: Loss of energy, but temporary maintenance of temperature through internal processes.

It is, here as elsewhere, our great physicist, v. HELMHOLTZ, who has proposed a very simple theory and supported it with figures. These latter we shall omit, conformably to the plan of this article, and consider only HELMHOLTZ's line of reasoning.

v. HELMHOLTZ starts from the KANT-LAPLACE theory of the formation of the solar system, and explains first how the present high temperature of the Sun has come about. Originally, the Sun must have been a widely extended thin nebula of low temperature, which has arrived at its present form through condensation. Such a condensation is nothing more than a falling of the particles of the nebula toward the center, which will, of course, generate heat, just as we have seen is the case in the discussion of the meteoric hypothesis of the conservation of the solar energy. The amount of heat evolved in this way is independent of the time during which the condensation takes place. Were it to take place instantly, the temperature produced would be about 28,611,000°. Since, however, it has been accomplished during an enormously long period of time, so high a temperature as this has never been reached, on account of the constant loss of energy by radiation. Now, since the upper parts of the Sun are gaseous, v. HELMHOLTZ assumed condensation to be still in progress, and in a degree such that the heat thus evolved very nearly compensates for the reduction in temperature.

It is further possible to compute that a contraction of the solar diameter by the ten thousandth part — *i. e.* about 0″.2 — will set free an amount of heat sufficient to raise the temperature of the Sun 2,861°, a quantity sufficient to supply the annual loss of 2°.9 for thirteen hundred years.

The fall of solar material affords therefore a vast amount of heat, which, however, is associated with a constant diminution of the solar diameter; and now arises the question as to whether or not astronomers are in a position to establish this reduction in diameter demanded by the HELMHOLTZ theory.

The determination of the diameter of the Sun is attended with great difficulties, and it is safe to say that such a reduction could be detected only when amounting to at least 1″. With constant solar temperature, this amount would be reached only after six thousand five hundred years; or, in other words, the diminution in the diameter of the Sun resulting from the HELMHOLTZ theory would with our present accuracy of measurement remain undiscoverable for many thousand years. The results of observation therefore afford no ground for doubting the conservation of the solar temperature, the theoretical possibility of which is raised above all doubt. Naturally, there must at last come a time when the possibility of further condensation is at an end, and then an actual diminution in temperature will begin.

We approach the end of our discussion. We have learned the vast amount of the stream of energy pouring out from the Sun, and we have been able to assert that all the vivifying forces of our Earth will remain unchanged for an immeasurable series of thousands of years. This period of time, so enormous for our conception, is but an instant according to the timepiece of the universe. Inevitably the time will come when, according to the classical utterance of DUBOIS REYMOND, the last Eskimo will wretchedly freeze at the equator by the light of a tallow-dip, and the last moment will not fail when all life upon the ice-bound earth will have ceased, and with it the last knowledge of all the thousands of years of strifes and battles of the human race, and of all of its acquisitions of civilization. Death is the end not for the individual alone; it is also, of all things upon this world, the end.

PLANETARY PHENOMENA FOR JANUARY AND FEBRUARY, 1899.

By Professor Malcolm McNeill.

January.

Eclipse. There will be a partial eclipse of the Sun on January 11th, visible in the northwestern portion of North America and in northeastern Asia. It will begin just before sunset in the States north of California, and will not be seen at all in other portions of the United States.

Mercury is a morning star throughout the month, and may be seen just before sunrise on any clear morning. It is at its greatest western elongation on January 11th, when it rises about an hour and three quarters before the Sun.

Venus is also a morning star, and rises about three hours before sunrise throughout the month. It is at its greatest brilliancy early in January, and may then be easily seen in full sunlight. It moves 23° eastward and 3° southward during the month, along the borders of the constellations *Ophiuchus* and *Scorpio*, and on January 25th passes about 3° north of *Saturn*.

Mars is in fine position for observation, being above the horizon practically the entire night. It is in opposition to the Sun on January 18th. Its motion is retrograde (westward) about 12°, and also 3° northward during the month among the stars of the constellation *Gemini*. It makes its nearest approach to the Earth on January 15th, when it is a little more than 60,000,000 miles distant from us. This is nearly the maximum opposition distance; and the planet, although the most conspicuous object in that portion of the sky, will be only about one third as bright as it is at an opposition in August, when its distance is only 35,500,000 miles.

Jupiter is a morning star, rising a little after midnight at the end of the month. It moves about 3° eastward and 1° southward during January in the constellation *Libra*.

Saturn is also a morning star, but does not rise until about an hour and a half before sunrise on January 1st. It moves about 3° eastward during the month, somewhat north of the stars forming the tail of the Scorpion.

Uranus is also a morning star, rising about an hour earlier than *Saturn*, but it does not attain an altitude great enough for easy visibility before sunrise.

Neptune is in the eastern part of *Taurus*, too faint to be seen without a telescope.

FEBRUARY.

Mercury is a morning star until February 27th. It then passes superior conjunction with the Sun and becomes an evening star, but throughout the month, except possibly during the first week, it is too near the Sun to be seen.

Venus is still a morning star, and rises about three hours before the Sun, except during the last third of the month, when the interval is somewhat shortened. It reaches its greatest western elongation on February 10th. It moves about 31° eastward through the constellation *Sagittarius*.

Mars is above the horizon nearly the whole night, not setting until nearly sunrise. It moves westward (retrogrades) until February 27th about 5°, somewhat south of *Castor and Pollux*, the principal stars of the constellation *Gemini*. After February 27th it begins to move eastward. Its distance from the Earth changes from 64,000,000 miles, on February 1st, to 80,000,000 miles, on March 1st, and its brightness diminishes about thirty per cent. during the month.

Jupiter rises earlier, before 11 P.M., at the close of the month. It is nearly stationary in the extreme western part of the constellation *Libra*, moving less than 1° eastward until February 24th, and then moving slightly westward during the remainder of the month.

Saturn is a morning star, rising a little after 2 A.M. at the end of the month. It is on the border of the constellations *Scorpio* and *Sagittarius*, and moves about 2° eastward.

Uranus rises about an hour before *Saturn*. It is about 5° north of *Antares*, the principal star of the constellation *Scorpio*.

Neptune is in the eastern part of *Taurus*.

PHASES OF THE MOON, P. S. T.

			H. M.			H. M.
Last Quarter,	Jan.	4,	7 21 P. M.	Feb.	3,	9 24 A. M.
New Moon,	Jan.	11,	2 50 P. M.	Feb.	10,	1 32 A. M.
First Quarter,	Jan.	18,	8 36 A. M.	Feb.	17,	12 52 A. M.
Full Moon,	Jan.	26,	11 34 A. M.	Feb.	25,	6 16 A. M.

THE SUN.

1898.	R. A. H. M.	Declination. ° ′	Rises. H. M.	Transits. H. M.	Sets. H. M.
Jan. 1.	18 47	− 23° 0′	7 27 A.M.	12 4 P.M.	4 41 P.M.
11.	19 31	− 21 48	7 26	12 8	4 50
21.	20 14	− 19 53	7 23	12 12	5 1
Feb. 1.	21 0	− 17 4	7 13	12 14	5 15
11.	21 40	− 14 0	7 2	12 14	5 26
21.	22 19	− 10 31	6 50	12 14	5 38
Mar. 1.	22 49	− 7 33	6 39	12 13	5 47

MERCURY.

1898.	R. A. H. M.	Declination. ° ′	Rises. H. M.	Transits. H. M.	Sets. H. M.
Jan. 1.	17 24	− 20 13	5 52 A.M.	10 40 A.M.	3 38 P.M.
11.	17 49	− 21 48	5 44	10 26	3 6
21.	18 41	− 23 0	6 1	10 38	3 16
Feb. 1.	19 48	− 22 20	6 22	11 2	3 42
11.	20 54	− 19 27	6 38	11 29	4 20
21.	22 2	− 14 16	6 49	12 0 M.	5 11
Mar. 1.	22 58	− 8 27	6 50	12 21 P.M.	5 52

VENUS.

1898.	R. A. H. M.	Declination. ° ′	Rises. H. M.	Transits. H. M.	Sets. H. M.
Jan. 1.	16 11	− 16 35	4 25 A.M.	9 27 A.M.	2 29 P.M.
11.	16 33	− 17 9	4 9	9 10	2 11
21.	17 3	− 18 13	4 4	9 0	1 56
Feb. 1.	17 43	− 19 21	4 5	8 57	1 49
11.	18 25	− 19 57	4 10	8 59	1 48
21.	19 2	− 19 52	4 6	9 5	1 54
Mar. 1.	19 46	− 19 14	4 17	9 9	2 1

MARS.

1898.	R. A. H. M.	Declination. ° ′	Rises. H. M.	Transits. H. M.	Sets. H. M.
Jan. 1.	8 34	+ 22 48	6 31 P.M.	1 53 A.M.	9 15 A.M.
11.	8 20	+ 23 55	5 31	12 59	8 17
21.	8 3	+ 24 55	4 26	11 58 P.M.	7 30
Feb. 1.	7 46	+ 25 39	3 22	10 57	6 32
11.	7 34	+ 25 54	2 29	10 6	5 43
21.	7 27	+ 25 51	1 45	9 21	4 57
Mar. 1.	7 27	+ 25 37	1 14	8 49	4 24

JUPITER.

1898.	R. A. H. M.	Declination. ° ′	Rises. H. M.	Transits. H. M.	Sets. H. M.
Jan. 1.	14 17	− 12 26	2 16 A.M.	7 33 A.M.	12 50 P.M.
Feb. 1.	14 30	− 13 26	12 27	5 45	10 59 A.M.
Mar. 1.	14 33	− 13 35	10 45 P.M.	3 58	9 11

SATURN.

1898.	R. A. H. M.	Declination. ° ′	Rises. H. M.	Transits. H. M.	Sets. H. M.
Jan. 1.	17 7	− 21 30	5 41 A.M.	10 24 A.M.	3 7 P.M.
Feb. 1.	17 21	− 21 45	3 52	8 35	1 18
Mar. 1.	17 29	− 21 50	2 11	6 54	11 37

Uranus.

Jan.	1.	16 17	− 21 13	4 48 A.M.	9 32 A.M.	2 16 P.M.
Feb.	1	16 22	− 21 26	2 54	7 37	12 20
Mar.	1.	16 25	− 21 32	1 7	5 50	10 33 A.M.

Neptune

Jan.	1.	5 29	+ 21 55	3 25 P.M.	10 44 P.M.	6 3 A.M.
Feb.	1.	5 26	+ 21 54	1 20	8 39	3 58
Mar.	1.	5 25	+ 21 54	11 29 A.M.	6 48	2 7

Eclipses of *Jupiter's* Satellites, P. S. T.

(Off left-hand limb as seen in an inverting telcscope.)

			H. M.
II, D,	Jan.	3.	11 33 P.M.
I, D,		8.	2 36 A.M.
II, D,		11.	2 6 A.M.
II, R,		11.	4 23 A.M.
I, D,		15.	4 29 A.M.
II, D,		18.	4 40 A.M.
I, D,		24.	12 51 A.M.
II, R,		28.	10 47 P.M.
I, D,		31.	2 44 A.M.
I, D,	Feb.	4.	11 5 P.M.
I, R,		5.	1 21 A.M.
III, R,		5.	12 46 A.M.
I, D,		7.	4 47 A.M.
I, D,		8.	11 5 P.M.
II, D,		12,	1 39 A.M.
II, R,		12,	3 55 A.M.
III, D,		13.	1 0 A.M.
III, R,		13.	2 43 A.M.
I, D,		16.	12 58 A.M.
I, D,		23.	2 51 A.M.
I, D,		24,	9 20 P.M.

NOTICES FROM THE LICK OBSERVATORY.*

PREPARED BY MEMBERS OF THE STAFF.

THE *LEONIDS* OF 1898.

The meteors from this radiant were again observed this year, continuing the observations of 1897. As it was possible that there might be a considerable display, more attention was paid to them than last year.

The following table shows the results of my 1898 observations:

Date. 1898.	Time.	Interval.	No. of Meteors.	Average per Hour.
Nov. 11.	$13^h\ 20^m$ to $15^h\ 10^m$	$1^h\ 50^m$	8	4.4
12.	12 55 — 14 55	2 0	10	5.0
13.	13 0 — 16 30	3 30	38	10.9
14.	13 38 — 13 53	0 15	8	43.8
14.	14 24 — 16 0	1 36	73	
15.	13 15 — 13 45	0 30	4	8.0
16.	13 37 — 14 7	0 30	8	14.0
16.	15 2 — 15 32	0 30	6	

The absence of the Moon during the entire period was very favorable. The nights of the 11th, 12th, 13th, 15th, and 16th were clear during the times of observation, and generally the atmosphere was very transparent. The earlier hours of observation on the 14th were clear, but, later, haze overspread the sky, which became so thick at 16^h as to prevent further observation.

It was expected that the maximum would occur on the 13th, but as will be seen from the foregoing table of results, meteors were most frequent on the 14th, reaching an average of 43.8 per hour during the time of observation — nearly two hours. This average would be considerably increased by taking into account

* Lick Astronomical Department of the University of California.

those meteors not seen by a single observer. The results are entirely comparable, as they are made under as near identical conditions as possible.

The characteristics of the *Leonids* were clearly brought out: rather slow of motion, strong trains, and bluish-white in color, deepening to decided green in the brightest ones. These features were so marked that it was possible to distinguish meteors from other swarms in this way, and as a matter of fact two such on the 13th were rejected as not being *Leonids*, although they came apparently from the *Leonid* radiant.

On the 11th, 12th, and 13th the meteors were charted on star maps, and as the *Leonids* were not too numerous to prevent those from other radiants being included, all meteors seen within the limits of the map were included. On these nights the *Leonids* were in the minority. Many of those seen were observed to come from the direction of *Gemini*. Not only were the *Leonids* most numerous on the night of the 14th, but the brightest ones of the shower appeared then also. The first (and finest) of two fell at $13^h\ 46^m\ 44^s$ P. S. T., the meteor itself being visible for two or three seconds. It came almost exactly from the radiant, and at its brightest was 30 to 40 times as bright as *Venus*. Its apparent path hardly exceeded 10 degrees. The meteor brightened up rapidly, passing just north of δ *Leonis*, where it exploded, the fragments soon disappearing. Its color at first was the usual bluish-white, but as it brightened the color changed, until at the time of explosion it was of a light but brilliant green. Immediately after the disappearance of the meteor, the debris cloud became very noticeable, and as there was an almost perfect calm, it remained near the same place for fifteen or twenty minutes, its form and brightness changing but little. The general appearance of this cloud to the naked eye was that of a splendid comet with a tail some 3° long, pointing to the northeast. To the eye its color was a dull white, or slightly tinted with pink. About five minutes after, the cloud was examined with the 4-inch CLARK comet-seeker. Its form was still *very sharply* outlined, rather irregular and full of brighter knots. There was a bright secondary branch making an angle of about 60° with the main stream. There was so little disturbance from the wind, that it seemed as if the branch must have been the debris from a fragment of the meteor. The meteor cloud was compared with the Great Nebula in *Andromeda*, and was seen to be very much larger and

brighter than the latter. In the telescope the color was a bright rose-pink.

The head of the cloud immediately after its formation was in α 11^h 10^m and $\delta + 24°$. At 14^h 13^m the same part of the cloud occupied the position α 11^h 0^m and $\delta + 16°$. The cloud was still plainly visible, although much fainter, at 14^h 29^m, 42 minutes after the fall of the meteor.

At 14^h 37^m $18^s \pm 5^s$ another bright *Leonid* fell near the eastern horizon. There was considerable haze there at the time, but even through this it was very brilliant, green in color, and left a bright cloud where it fell. Five minutes after the meteor's fall the cloud was still very distinct. This meteor was several times as bright as *Venus*.

Shortly before the close of our observations on the 13th, an unusually bright meteor was visible close to the southern horizon. Its course was almost vertical, which precluded its being a *Leonid*.

C. D. PERRINE.

November 17, 1898.

THE *LEONID* SHOWER IN 1898.

On the night of November 11th, a three hours' watch for *Leonids* was rewarded by only six, none of them very brilliant. Saturday night, November 12th, the sky was very clear, as on the preceding night, and the north wind, which had made the watchers very uncomfortable on Friday night, had greatly moderated its violence. Forty-one meteors were counted and charted in two hours from 13^h 45^m to 15^h 45^m P. S. T., twenty-four of which were classified as *Leonids*. Many of the others came from the constellation *Gemini*. No unusually bright meteors were noted. Sunday night, November 13th, the sky was somewhat hazy. Sixty-six meteors were charted, of which twenty-seven were counted as *Leonids*. Several of these were bright, but the only unusually brilliant meteor seen was not a *Leonid*. This one—a brilliant green in color—fell almost vertically in the south at about 16^h 25^m P. S. T., but left no smoke-cloud when it burst. The watch was continued for four hours from 12^h 30^m, Monday night, November 14th, the sky was hazy when I began to watch at 13^h 30^m P. S. T., and by 16^h the clouds had gathered too thickly to make further count possible. But in spite of this, the display of *Leonids* was far better than on preceding nights, in point of brilliancy as well as in the numbers of meteors

seen. In 140 minutes between the hours noted, 70 *Leonids* were counted, 36 of these falling in the hour from 14^h 25^m to 15^h 25^m. At 13^h 46^m $45^s \pm 2^s$ P. S. T., a magnificent *Leonid* lighted up the entire sky and threw strong shadows. My attention was diverted at the instant; so I leave further description of the meteor itself to others. The train, when seen, extended a little north of the line joining δ *Leonis* and 93 *Leonis*, with a bright, bluish-white smoke-cloud near the former star. For many minutes this cloud had all the appearance of a bright naked-eye comet. Gradually it became more diffuse, and drifted toward the south into a nearly horizontal position. At 14^h 12^m it extended from δ *Leonis* toward κ *Leonis*, the southern part being the denser. It was visible for nearly forty-five minutes altogether. Another brilliant green *Leonid*, several times as bright as *Sirius*, fell at 14^h 37^m $13^s \pm 5^s$ from a point a little north of β *Leonis* toward the eastern horizon. When it burst, it left a smoke-cloud —bluish-white—that was visible even in the thick haze for at least five minutes. Several other *Leonids* with long bright trains were seen—but only the two noted left smoke-clouds.

R. G. AITKEN.

November 17, 1898.

THE *LEONIDS* IN 1898.

The *Leonids* were observed and charted at the University of the Pacific, College Park, Cal., with the following results: November 12th, 14^h to 17^h 30^m P. S. T., 75 meteors were seen within 25° of the radiant, 64 of them being classified as *Leonids;* November 13, 13^h 40^m to 17^h 0^m, 45 meteors, 37 being *Leonids;* November 14, 13^h 45^m to 15^h 15^m, 34 meteors, 26 being *Leonids.* Clouds stopped the observations on the 14th, and prevented work on the 15th. On the 14th a count was also made by Mr. NORMAN TITUS, a student, at his home in West Side (numbers not given). My best night was Saturday, November 12th, though it would have been surpassed by Monday, the 14th, but for the fog—the average number of *Leonids* per hour on the two nights for the time of observation being 18 and 20, respectively.

H. D. CURTIS.

Family Likeness of the Comets *i* 1898 (Brooks), and 1881 IV (Schaeberle).

In an interesting theorem of mechanics, it is shown that, if a body start from a state of rest, so far as concerns its motion to or from the Sun, and at an infinite distance from the Sun, and be thereafter subjected to the mutual attractions only of the Sun and itself, it will acquire, by reason of these attractions, just sufficient velocity to cause it to describe a parabola having the Sun at its focus. If it start at less than an infinite distance, its velocity at any point in its orbit will be less than that which obtains in a parabola for the same distance from the Sun, and in this case its path will be an ellipse. And if it start with initial velocity towards the Sun, the orbit which it will then describe will be an hyperbola.

These propositions have well-known applications in the case of comets. A comet may be situated so far from all attracting bodies, as to be next to free from the influence of any predominating force. Suppose a comet so situated to drift into the region where the Sun exercises what little predominating force there is. Then, if the comet is nearly or quite in a state of rest, so far as concerns its motion to or from the Sun, it will begin to gravitate towards the Sun, and will describe about it an orbit which will be indistinguishable from a parabola. If, in its movement towards the Sun, its velocity becomes accelerated from any cause other than the mutual attractions of itself and the Sun, as, for example, by the action of the planets, its orbit about the Sun will be changed from a parabola to an hyperbola; and, on the other hand, if its velocity is diminished, its orbit will be changed from a parabola to an ellipse. In the latter case, the comet will become periodic, and the shortness of its period will depend upon the extent to which its velocity has been diminished. In this way, the planet *Jupiter* is responsible for the remarkable changes that have taken place in the orbits of a considerable number of comets. At present there are known about twenty-five comets, with periods less than that of *Jupiter*, and with aphelion distances not very different from the mean distance of this planet from the Sun. These comets have become permanent members of the solar system by reason of *Jupiter's* attraction, and although they move in very different orbits, they are designated as *Jupiter's* Family of Comets.

In another sense we also have families of comets. Recurring to the principles above, it is evident, that if there are two comets

in the same region of space at an indefinitely great distance from the Sun, which begin to gravitate towards the Sun, they will move in the same general direction and at the same general rate. One may reach its point of nearest approach to the Sun many years before the other, but on comparing their orbits, it will be found that they have essentially the same dimensions and essentially the same situation in space. Comets having orbits with such relations are said to belong to the same family, indicating thereby that they at one time were situated in the same region of space, and were affected by the same general conditions of rest or motion.

Such a relation exists between the comet discovered October 20th, by Dr. BROOKS, of Geneva, New York, and that discovered July 13, 1881, by Professor SCHAEBERLE, at Ann Arbor. From my observations of October 21st, 23d, and 25th, I have computed the elements of Comet BROOKS with the following results:

$$T = 1898.13518 \text{ Gr. M. T.}$$

$$\left.\begin{array}{rl} \omega = & 123^\circ\ 22'\ 21''.3 \\ \Omega = & 96\ \ 10\ \ \ 6.2 \\ i = & 140\ \ 18\ \ 58.1 \end{array}\right\} \begin{array}{c}\text{Ecliptic and} \\ \text{Mean Equinox of 1898.0}\end{array}$$

$$\log q = 9.878746$$

$$\text{O}-\text{C}: \quad \Delta\lambda' \cos\beta' = +0''.6, \quad \Delta\beta' = -1''.6.$$

As the result of a definitive investigation of the orbit of Comet SCHAEBERLE, Dr. STECHERT arrived at the following parabolic elements as being those which represent the observations as satisfactorily as any system that can be obtained.

$$T = 1881, \text{ August } 22.3431935 \text{ Berlin M. T.}$$

$$\left.\begin{array}{rl} \omega = & 122^\circ\ \ 7'\ 18''.61 \\ \Omega = & 97\ \ \ 2\ \ 36.93 \\ i = & 140\ \ 13\ \ 54.04 \end{array}\right\} \text{Mean Equinox, 1881.0}$$

$$\log q = 9.8017757$$

It is to be noted that the longitudes of the nodes and the inclination of these two orbits are nearly the same, consequently the planes of the two orbits are nearly coincident. Moreover, the dimensions of the orbits and the positions on their planes, as determined by q and ω, are almost the same. Hence, the two comets describe essentially the same path in space, and the question of their identity arises.

The Comet 1881 IV was under observation from July 13 to

October 18, 1881. During this time it described a heliocentric arc of 167°, namely, 77° before and 90° after perihelion passage. The length of this arc is sufficient to afford a very accurate determination of the orbit, and to give us confidence in the results obtained by Dr. STECHERT. The most probable elements which he obtained were hyberbolic, differing so little, however, from the parabolic ones given above, that he finally selected the latter as the definitive elements. In his attempts to vary the eccentricity, he found that the observations could be represented fairly well by all orbits from an ellipse corresponding to a periodic time of 100,000 years to an hyperbola having an eccentricity equal to 1.0003. If the orbit is included within these limits, as seems reasonably certain, the Comet 1881 IV is not one of short period, and cannot have returned by this time. Moreover, Comet BROOKS has been following closely the ephemeris computed from my elements, and has not given any indication of departure from parabolic motion. These circumstances preclude the possibility of these comets being identical. They may certainly, however, be said to belong to the same family.

W. J. HUSSEY.

LICK OBSERVATORY, November 15, 1898.

THE SMALL BRIGHT NEBULA NEAR *MEROPE*.

In No. 3018 of *Astronomische Nachrichten*, Professor BARNARD called attention to a small nebula near the star *Merope*, which he had discovered by visual observation with the 12-inch telescope of the Lick Observatory. He describes the nebula as round, bright — though not easily visible on account of its proximity to the star,— and apparently not connected with the nebulous system of the *Pleiades*. It turned out that the nebula had previously been photographed; but its character is sufficiently different from other nebulosities in the same region to justify its treatment by BARNARD as an individual nebula.

This nebula is well shown on some photographs which I have recently obtained with the 3-foot reflector presented to the Lick Observatory by Mr. CROSSLEY. My attention was, in fact, attracted by it before I recalled the note by Professor BARNARD, mentioned above. Though small, it is by far the brightest nebula in the *Pleiades*. Of the plates which I have obtained, the one which shows it best received the shortest exposure (fifteen minutes). I have no doubt that it can be photographed with the CROSSLEY reflector in five minutes, or even in less time than this.

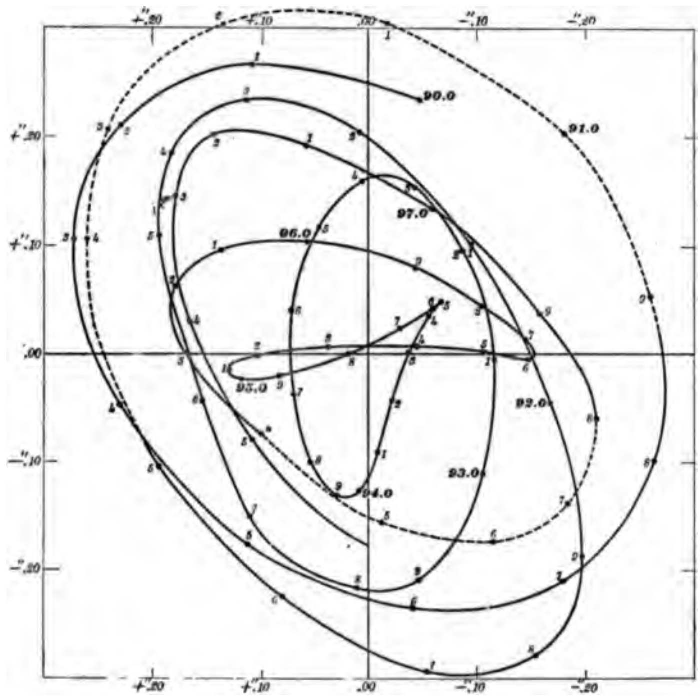
The nebula, as shown on the photographs, is roughly pentagonal in shape, the most salient angle pointing directly to *Merope*. From opposite sides, symmetrically placed with respect to the line joining the nebula and the star, two wisps of nebulosity stream away, and join the other nebulous wisps which are characteristic of the region. It is possible that this appearance may be illusory, as the wisps of nebulosity may be continued on the other side of the nebula, instead of proceeding from it; there is not a sufficient interval on the plate between the nebula and the star to allow this supposition to be tested. The angular form of the nebula, however, seems to show that it is not a cometary or planetary nebula fortuitously placed in line with a nebulous cluster, and it is altogether probable that it is a part of the general nebulous system of the *Pleiades*.

The photographs are on a large scale ($1^{mm} = 38''.7$), and are of excellent definition. Stars are shown double which are single on the Paris map. The plates were coated on the back to prevent "halation." JAMES E. KEELER.

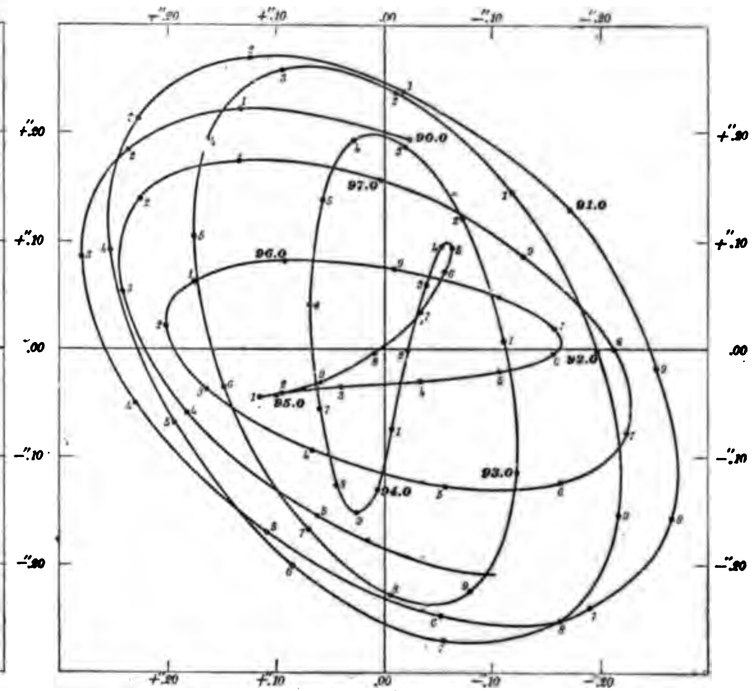
THE MOTION OF THE POLE.

In connection with an investigation of the revised elements of the motion of the Earth's pole, based on modern observations, Dr. S. C. CHANDLER gives in *Astronomical Journal*, 446, diagrams for comparison of its observed course between 1890 and 1897.5, with that predicted by the geometrical theory deduced some years ago from observations from 1825 to 1893. We have reproduced these diagrams here, as they are of very great interest, inasmuch as they afford a graphic proof of the truth of the theory that is most convincing. A careful comparison will show that, as Dr. CHANDLER says, "what differences exist are of a subordinate nature; that is, they manifestly relate to the need of slight emendation of the numerical constants used, and not to the correctness of the geometrical theory." We may, therefore, take it as demonstrated "that the Earth's axis is subject to a composite motion arising from a uniform circular revolution in 428 days, and a very eccentric central elliptic motion obeying the law of proportionality of times to areas about a mean position on the Earth's surface." Subsequent observations will perfect the details of the theory, but are not likely to affect the main conclusions. R. G. AITKEN.

TRAJECTORY OF THE POLE.



ADJUSTED FROM OBSERVATION.



PREDICTED BY THEORY.

The Harvard Conference of Astronomers and Physicists.

A full report of the second Annual Conference of Astronomers and Physicists, held at the Harvard College Observatory on August 18th, 19th, and 20th, is given by Professor M. B. SNYDER, in *Science* for October 7, 1898. From this account, and a shorter one in the *Astrophysical Journal* for October, the following notes have been taken.

The meetings were held in the drawing-room of Professor PICKERING's residence, and were presided over alternately by Professor J. R. EASTMAN, of the U. S. Naval Observatory, and Professor GEORGE E. HALE, Director of the Yerkes Observatory. Ninety-three persons were registered as attending the Conference. Very many interesting and important papers, touching upon nearly every line of astronomical work, were read and discussed. Abstracts of these may be found in Professor SNYDER'S report and in the *Astrophysical Journal* for November.

Ample opportunity was afforded to examine the instruments and work of the Harvard College Observatory, the Blue Hill Meteorological Observatory, and other neighboring scientific institutions; and the meeting of the American Association in Boston, during the following week, added one more attraction for the visitors.

Aside from the scientific papers referred to, various matters of general interest were discussed by the Conference, the most important being the question of forming a permanent astronomical and astrophysical society. It was formally resolved that it was desirable to form such a society, and a committee, consisting of Professors HALE, COMSTOCK, PICKERING, NEWCOMB, and MORLEY, was appointed to report to the Conference on the subject. This committee subsequently presented the first draft of a constitution, and recommended that a meeting to effect a preliminary organization should be held on the Tuesday following.

The meeting was duly held, sixty-one persons having signified their wish to become charter members of the society. After a brief discussion, the same committee of five, with power to add four to its number, was appointed as the first council of the society. The duties of the council include the drafting of a constitution, the election of members to the society, arrangements for the next meeting, and similar matters.

A committee, consisting of Professors PICKERING, HALE, and

COMSTOCK, was appointed to consider the question of the proper organization and function of the U. S. Naval Observatory. The American Association for the Advancement of Science, at its meeting in Boston, appointed a committee, Professors PICKERING, MENDENHALL, and WOODWARD, for a similar purpose.

A committee was also appointed to co-operate with observers of the total solar eclipse of May 28, 1900, and to take such action as might be deemed necessary to secure the best results.

This committee, as finally named, consists of Professors NEWCOMB, BARNARD, CAMPBELL, and HALE, who have power to add to their number should this seem desirable.

HELIUM IN THE EARTH'S ATMOSPHERE.

Professors C. FRIEDLANDER and H. KAYSER have independently found helium in the atmosphere. E. C. C. BALY, in examining the spectrum of neon recently, identified six of the principal helium lines. Professor W. CROOKES states that in examining samples of the more volatile portions from liquid air, he had no difficulty in seeing the lines of helium in them.

From all these observations, it is evident that another constituent has been added to those previously known to exist in the Earth's atmosphere. R. G. AITKEN.

THE TELESCOPE FOR THE PARIS EXHIBITION OF 1900.

M. GAUTIER is at work upon a monster refracting telescope, which is to be one of the attractions of the Paris Exhibition of 1900. From published statements, it appears that the aperture is to be 49.2 inches and the focal length 196 feet 10 inches. The estimated cost is 1,400,000 francs. The telescope is to be mounted in a fixed horizontal position, the light from celestial objects being reflected into it by a huge plane mirror.

A NEW *ALGOL* VARIABLE.

Mr. EDWIN F. SAWYER communicates to the Boston Scientific Society the particulars of a new *Algol* variable just discovered by him. The star is in *Ophiuchus*. It is B. D. + 12°.3557, the position of which (1900) is R. A. $18^h\ 26^m\ 1^s$, Decl. + $12^h\ 32^m\ 36^s$. The epoch of minimum is October 3.54233 G. M. T., and the period is $21^h\ 21^m$. The range of variation is from 7.0 to 7.5 magnitude.— *Science Observer, Special Circular No. 122, October 27, 1898.*

Resemblance of the Orbit of Brooks's Comet (1898 *i*) to that of Schaeberle's Comet of 1881 (1881 IV).

There is a striking similarity between the orbits of these two comets, as will be seen from the following comparison of their elements:—

	ω	Ω	i	q
Schaeberle,	122° 8′	97° 17′	140° 14′	0.6335
Brooks,	123 22	96 10	140 19	0.7564

The elements of Schaeberle's Comet are the definitive elements by Stechert brought forward to 1898.0; those of Brooks's Comet are by Hussey from two-day intervals. Schaeberle's Comet was observed for three months; and the resulting orbit shows that it is not possible for Brooks's Comet to be a return of Schaeberle's. The resemblance is so close, however, as to indicate a strong family connection, and the necessity for as good a series of observations of the present comet as possible.

C. D. Perrine.

October 26, 1898.

Astronomical Telegrams.

(Translations).

Boston, Mass., October 21, 1898.

To Lick Observatory: (Received 9:55 A.M.)

A bright comet was discovered by Brooks, October 20.500 G. M. T., in R. A. $14^h\ 32^m\ 2^s.0$; Decl. $+ 60°\ 26'\ 0''$. The comet is round, and is moving southeast.

(Signed) John Ritchie, Jr.

Lick Observatory, October 22, 1898.

To Harvard College Observatory: (Sent 10:30 A.M.)

Comet Brooks was observed by W. J. Hussey, October 21.6352, in R. A. $15^h\ 3^m\ 35^s.6$; Decl. $+ 57°\ 55'\ 18''$.

Lick Observatory, October 24, 1898.

To Harvard College Observatory: (Sent 10:10 A.M.)

Comet Brooks was observed by W. J. Hussey, October 23.6280 G M. T., in R. A. $15^h\ 42^m\ 57^s.1$; Decl. $+ 52°\ 49'\ 22''$.

Lick Observatory, October 25, 1898.

To Harvard College Observatory: (Sent 11:00 A.M.)

Comet Brooks was observed by W. J. Hussey, October 24.6850 G. M. T., in R. A. $16^h\ 0^m\ 6^s.1$; Decl. $+ 49°\ 50'\ 19''$.

Lick Observatory, October 26, 1898.

To Harvard College Observatory: (Sent 10:20 A.M.)

Elements and ephemeris of Comet BROOKS were computed by W. J. HUSSEY, as follows:—

$$T = 1898, \text{ November } 23.14 \text{ G. M. T.}$$

$$\left.\begin{aligned} \omega &= 123^\circ \; 22' \\ \Omega &= \;\;96 \quad 10 \\ i &= 140 \quad 19 \end{aligned}\right\} \begin{array}{c}\text{Ecliptic and} \\ \text{Mean Equinox of 1898.0}\end{array}$$

$$\text{natural } q = 0.7564$$

[The ephemeris is here omitted.]

Lick Observatory, October 26, 1898.

To Harvard College Observatory: (Sent 12:20 P.M.)

PERRINE finds close resemblance between the elements of BROOKS's Comet and those of SCHAEBERLE's Comet 1881 IV.

A NEW GAS.

In a paper read before the American Association for the Advancement of Science, August 23, 1898, Professor CHARLES F. BRUSH, recounts his experiments on the heat-conductivity of various gases at low pressures. His purpose is "to announce the discovery of a new gas, presumably elementary, and possessed of some extraordinary properties." In his account he says:* "I had long been engaged in high-vacua experiments, and had observed that glass apparatus, when highly exhausted and heated, evolved gas for an indefinite length of time, rapidly at first, then slower, but never stopping until the temperature was reduced. On cooling, rapid reabsorption took place, but was never complete, indicating that two or more gases had been evolved by heating, one of which was not reabsorbed by cooling. In other words, the absorption was selective. The truth of this conclusion was abundantly demonstrated subsequently."

Continuing his experiments, Professor BRUSH has been able to demonstrate the existence of a new gas, named by him *etherion*, and to show that its principal property is enormous heat-conducting capacity — at least one hundred times that of hydrogen, and three hundred times that of ordinary air. From his experiments on the relation between the relative heat-conductivity and the relative molecular velocity of gases, the investigator reaches the conclusion that the mean molecular velocity of

* *Science*, October 14, 1898.

the new gas is one hundred times that of hydrogen, or, at 32° F. temperature, more than one hundred and five miles per second. "At anything like this molecular velocity, it would be quite impossible for a gas to remain in the atmosphere, *unless the space above also contained it.*" And Professor BRUSH is inclined to believe that this is the case. We would have, therefore, in the form of this new gas an "interplanetary and interstellar atmosphere," which would account for the transmission of radiant energy through space, now attributed to the agency of the hypothetical ether.

It is hard to see how such a molecular medium can exist in space without offering sufficient resistance to the motions of celestial bodies to be detected by observation. It is generally agreed among astronomers that no evidence of such a resisting medium has been found hitherto, though certain cometary phenomena have led a few to suspect its existence.

Professor BRUSH'S discovery, if confirmed, is evidently as important to astronomers as to chemists, and further results will be awaited with interest. R. G. AITKEN.

November 2, 1898.

PHOTOGRAPHS OF COMET *i* 1898 (BROOKS).

The comet discovered by Mr. BROOKS, on October 20th, was photographed with the CROSSLEY 3-foot reflector on eleven consecutive nights — from November 4th to November 14th, inclusive — with exposures varying from four minutes to somewhat over one hour.

On the best photographs, taken on November 5th with an exposure of $1^h\ 10^m$, the extreme diameter of the coma is 0.25 inch = $4'.1$. A very narrow, straight tail extends from the center of the head to a distance of 1.4 inches, or $23'$. In appearance, the comet closely resembles Comet *b* 1894 (GALE), as photographed by BARNARD. The tail could not be seen with the large telescopes of the Observatory.

There is evidence on one of the plates that the nucleus of the comet was divided into two distinct masses on November 10th. As the guiding of the telescope was imperfect, it is not possible to speak positively on this point. At present, the CROSSLEY reflector is provided with no better arrangement for guiding (in the case of a comet), than a 4-inch finder of 8½ feet focal length, attached to one corner of the main telescope tube. A study of

the star-trails on the same plate makes it fairly certain that the observed division of the nucleus was real. A more detailed account of these observations will be printed in the *Astrophysical Journal.*

An excellent photograph of the comet was obtained on the night of November 3d, by Mr. H. K. PALMER, with the WILLARD 6-inch portrait-lens. It resembles closely the photographs taken with the 3-foot reflector, though the scale is, of course, very much smaller. The straight, narrow tail can be traced to a distance of about 45′. J. E. K.

ERRATUM.

No. 64, page 167, date line: *for* Vol. IX, *read* Vol. X.

MINUTES OF THE MEETING OF THE BOARD OF DIRECTORS, HELD IN THE ROOMS OF THE SOCIETY, NOVEMBER 26, 1898, AT 7:30 P.M.

President AITKEN presided. A quorum was present. The minutes of the last meeting were read and approved. The following members were duly elected:—

LIST OF MEMBERS ELECTED NOVEMBER 26, 1898.

Mr. LEO BRENNER	Manora-Sternwarte, Lussinpiccolo, Istrien.
Mr. CECIL G. DOLMAGE	22 Upper Merrion St., Dublin, Ireland.
Mr. J. A. DONOHOE	Vice-Prest. Donohoe-Kelly Banking Co., S. F., Cal.
LIBRARY OF ST. IGNATIUS COLLEGE . .	San Francisco, Cal.

The election of these members to date from January 1, 1899.

REPORT OF THE SPECIAL COMMITTEE ON THE BRUCE MEDAL. SUBMITTED NOVEMBER 26, 1898.

To the Board of Directors of the Astronomical Society of the Pacific:—

We, the undersigned committee on the BRUCE Medal, respectfully report as follows:—

At the meeting of the Board of Directors held on August 14, 1897 (see *Publications*, A. S. P., Vol. IX, page 205), your committee was authorized to procure the dies and to strike off one Gold Medal and nine bronze replicas.

After obtaining bids and designs from six of the best engravers, the contract for making the dies was awarded to Mr. ALPHÉE DUBOIS, of Paris. Regarding the execution of the designs, we beg to state that the figure of Mercury on the *obverse* was modeled after the original in the Musée du Louvre; and that, of four different designs submitted for the *reverse*, the one in which the inscription is surrounded by a laurel wreath was selected.*

The final plaster proofs having been found satisfactory, the engraver was authorized to harden the dies, which, together with the hubs and the ferrule of coining, were deposited with the French Mint in Paris, and its receipt, No. 3087, taken for the same.

The medals were then struck off, and have been delivered to the Secretary of the Society.

The medal is of 22-carat (916/000 fine) gold; its dimensions are:
diameter: 60 millimeters (the same as the seal of the Society);
thickness at the rim: 3 millimeters;
weight: 141.8 grammes (4.56 oz. troy).

* A half-tone cut of the medal is given in the frontispiece.

The cost of the dies and medals is as follows:—

Designing and engraving two steel dies (obverse and reverse); engraving two steel hubs (in relief); and the steel ferrule of coining.. ...	Frs. 2000 @ 5.173 =		$386 62
Price of gold metal....	Frs. 447 38 =	$86 48	
Striking Gold Medal..	50 05 =	9 68	
			96 16
Engraving recipient's name on Gold Medal..	Frs. 5 00		
Nine bronze replicas @ 2.15	19 35		
Four extra bronze replicas (required as a deposit by the French Mint)	8 60		
Four extra bronze replicas, Six bronze cuts } (Presented to A. DUBOIS)	21 50		
Two bronze cuts	4 30		
Silvering two cuts	2 00		
One square morocco case	6 00		
Nine round morocco cases @ 1.75	15 75		
Revenue stamps	50		
Packing and freight to New York	16 00		
	Frs. 99 00 @ 5.173 =		19 14
Duty on nine replicas and charges at New York			6 85
Marine insurance from Paris to San Francisco			60
Express from New York			1 25
Total			$510 62

The amount available from the Medal Fund ($250.00, plus interest $63.96), was	$313 96
and the sum advanced by the Treasurer from the General Fund (see resolution, Vol. IX, page 206) was	196 66
	$510 62

Your committee desires to acknowledge the aid given by Mr. A. H. BABCOCK in connection with the manufacture of the dies and medals.

Respectfully submitted,

E. S. HOLDEN,
F. R. ZIEL,
CHAUNCEY M. ST. JOHN,
Special Committee on the Bruce Medal.

The above report was accepted and adopted, and the committee discharged.

The Secretary reported that the nine bronze replicas had been forwarded as directed in the resolution of August 14, 1897; and that the Gold Medal for the year 1898 had been duly sent to Professor NEWCOMB, and its receipt acknowledged by him in the following letter:—

Mr. F. R. ZIEL, *Secretary:*— WASHINGTON, October 13, 1898.

DEAR SIR:—I have much pleasure in acknowledging receipt of your favor of the 3d inst., and also of the medal. The latter is certainly a splendid work of art, and will have an honored place among my choicest possessions. Please convey to the Society the renewed assurance of my very high appreciation of the honor done me.

Yours very respectfully,
(Signed) SIMON NEWCOMB.

The following resolutions were, on motion, adopted:—

Resolved, That a bronze replica of the BRUCE Medal be presented to each member of the Medal Committee, and to Mr. BABCOCK, in recognition of the services rendered by them.

Resolved, That the Committees on Publication and Library be authorized to make such changes in the list of corresponding institutions of this Society, from time to time, as they may deem proper.

Resolved, That Mr. PIERSON be authorized to draft a bill to be presented to Congress, for the free admission into this country of the dies of the BRUCE Medal, and to send it to Washington.

Adjourned.

MINUTES OF THE MEETING OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC, HELD IN THE ROOMS OF THE SOCIETY, NOVEMBER 26, 1898, AT 8 P. M.

President AITKEN presided. The minutes of the last meeting were approved. The Secretary read the names of new members duly elected at the Directors' meeting.

The following papers were presented:—

1. The Temperature of the Sun, II, by Professor Dr. J. SCHEINER (translated by F. H. SEARES).
2. The Development of Photography in Astronomy (abstract), by Professor EDWARD E. BARNARD.
3. The Surface of the Sun, by Miss ROSE O'HALLORAN.
4. Planetary Phenomena for January and February, 1899, by Professor MALCOLM MCNEILL.
5. A General Account of the Chabot Observatory-PIERSON Eclipse Expedition to India, in January, 1898, by Mr. CHAS. BURCKHALTER.

The meeting was notified that Mr. BURCKHALTER's lecture, illustrated by lantern-slides, would be given on Friday, December 2d, at 8 P.M., in the lecture-hall of the California Academy of Sciences.

Adjourned.

OFFICERS OF THE SOCIETY.

Mr. R. G. Aitken	*President*
Mr. C. B. Hill	*First Vice-President*
Miss R. O'Halloran	*Second Vice-President*
Mr. F. H. Seares	*Third Vice-President*
Mr. C. D. Perrine, Mr. F. R. Ziel	*Secretaries*
Mr. F. R. Ziel	*Treasurer*

Board of Directors—Messrs. Aitken, Hill, Keeler, Molera, Miss O'Halloran, Messrs. Perrine, Pierson, Seares, St. John, von Geldern, Ziel.

Finance Committee—Messrs. Pierson, von Geldern, Hill.

Committee on Publication—Messrs. Aitken, Seares, von Geldern.

Library Committee—Messrs. Seares, Geo. C. Edwards, Miss O'Halloran.

Committee on the Comet-Medal—Messrs. Keeler (*ex-officio*), Pierson, Burckhalter.

OFFICERS OF THE CHICAGO SECTION.

Executive Committee—Mr. Ruthven W. Pike.

OFFICERS OF THE MEXICAN SECTION.

Executive Committee—Mr. Francisco Rodriguez Rey.

NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only. Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book-keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the *Publications* for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of two dollars per volume to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to the Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the card.

The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States. The responsibility for the views expressed in the papers printed rests with the writers, and is not assumed by the Society itself.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery, stamped with the seal of the Society, at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific" at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.

PUBLICATIONS ISSUED BI-MONTHLY.

(February, April, June, August, October, December.)

GENERAL INDEX TO VOLUME X.

PUBLICATIONS

OF THE

ASTRONOMICAL SOCIETY

OF THE PACIFIC.

VOLUME X.

NUMBER 60.

1898.

SAN FRANCISCO

PRINTED FOR THE SOCIETY.

1898.

[Entered at Post Office at San Francisco, Cal. as second-class mail matter.]

CONTENTS.

PUBLICATIONS

OF THE

ASTRONOMICAL SOCIETY

OF THE PACIFIC.

VOLUME X.

NUMBER 61.

1898.

SAN FRANCISCO

PRINTED FOR THE SOCIETY.

1898.

[Entered at Post Office at San Francisco, Cal. as second-class mail matter.

CONTENTS.

PUBLICATIONS

OF THE

ASTRONOMICAL SOCIETY

OF THE PACIFIC.

VOLUME X.

NUMBER 63.

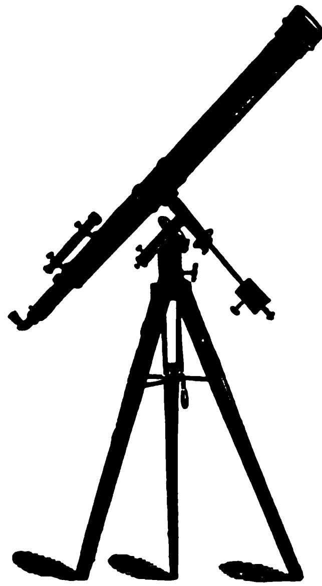
1898.

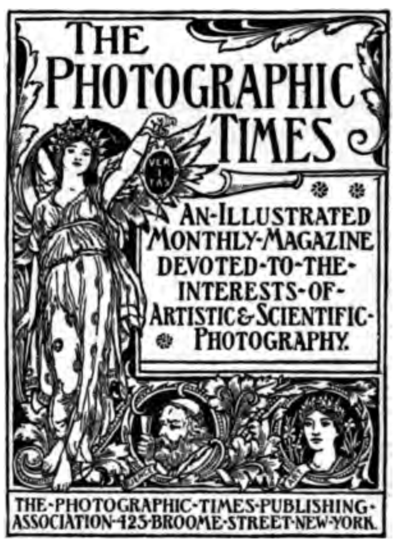
SAN FRANCISCO:

PRINTED FOR THE SOCIETY.

1898.

[Entered at Post Office at San Francisco, Cal., as second-class mail matter.




THE PHOTOGRAPHIC TIMES
AN·ILLUSTRATED MONTHLY·MAGAZINE DEVOTED·TO·THE· INTERESTS·OF· ARTISTIC & SCIENTIFIC· PHOTOGRAPHY.
THE·PHOTOGRAPHIC·TIMES·PUBLISHING· ASSOCIATION·423·BROOME·STREET·NEW·YORK.

CONTENTS.

PUBLICATIONS

OF THE

ASTRONOMICAL SOCIETY

OF THE PACIFIC.

VOLUME X.

NUMBER 64.

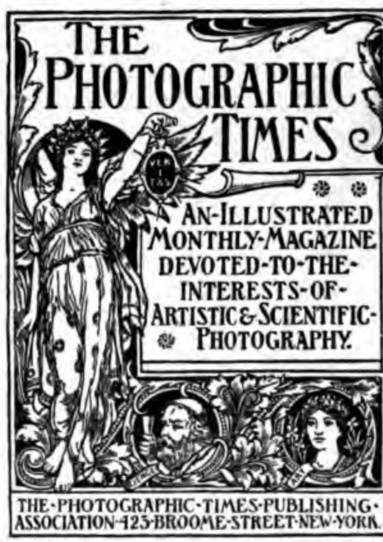
1898.

SAN FRANCISCO:

PRINTED FOR THE SOCIETY.

1898.

[Entered at Post Office at San Francisco, Cal., as second class mail matter.


THE PHOTOGRAPHIC TIMES
AN·ILLUSTRATED MONTHLY·MAGAZINE DEVOTED·TO·THE· INTERESTS·OF· ARTISTIC & SCIENTIFIC· PHOTOGRAPHY.
THE·PHOTOGRAPHIC·TIMES·PUBLISHING· ASSOCIATION·423·BROOME·STREET·NEW·YORK.

CONTENTS.

PUBLICATIONS

OF THE

ASTRONOMICAL SOCIETY

OF THE PACIFIC.

VOLUME X.

NUMBER 65.

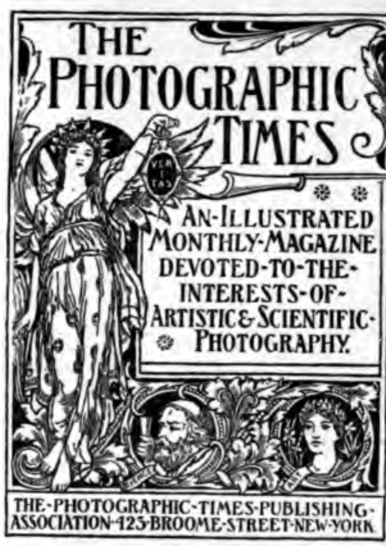
1898.

SAN FRANCISCO:

PRINTED FOR THE SOCIETY.

1898.

[Entered at Post Office at San Francisco, Cal., as second-class mail matter.]


THE PHOTOGRAPHIC TIMES
AN·ILLUSTRATED MONTHLY·MAGAZINE DEVOTED·TO·THE· INTERESTS·OF· ARTISTIC & SCIENTIFIC· PHOTOGRAPHY.
THE·PHOTOGRAPHIC·TIMES·PUBLISHING· ASSOCIATION·423·BROOME·STREET·NEW·YORK

CONTENTS.

DATE DUE
